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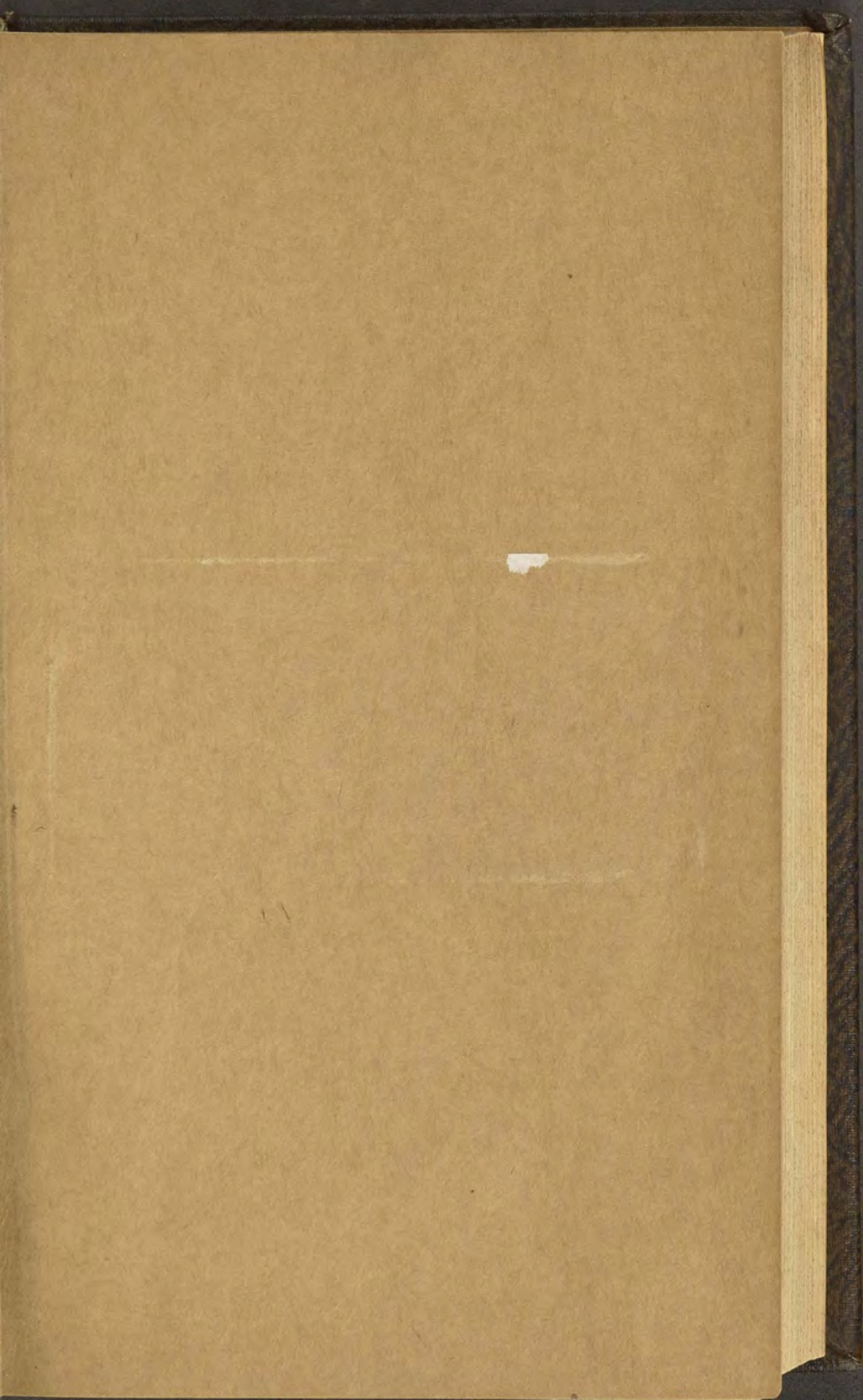
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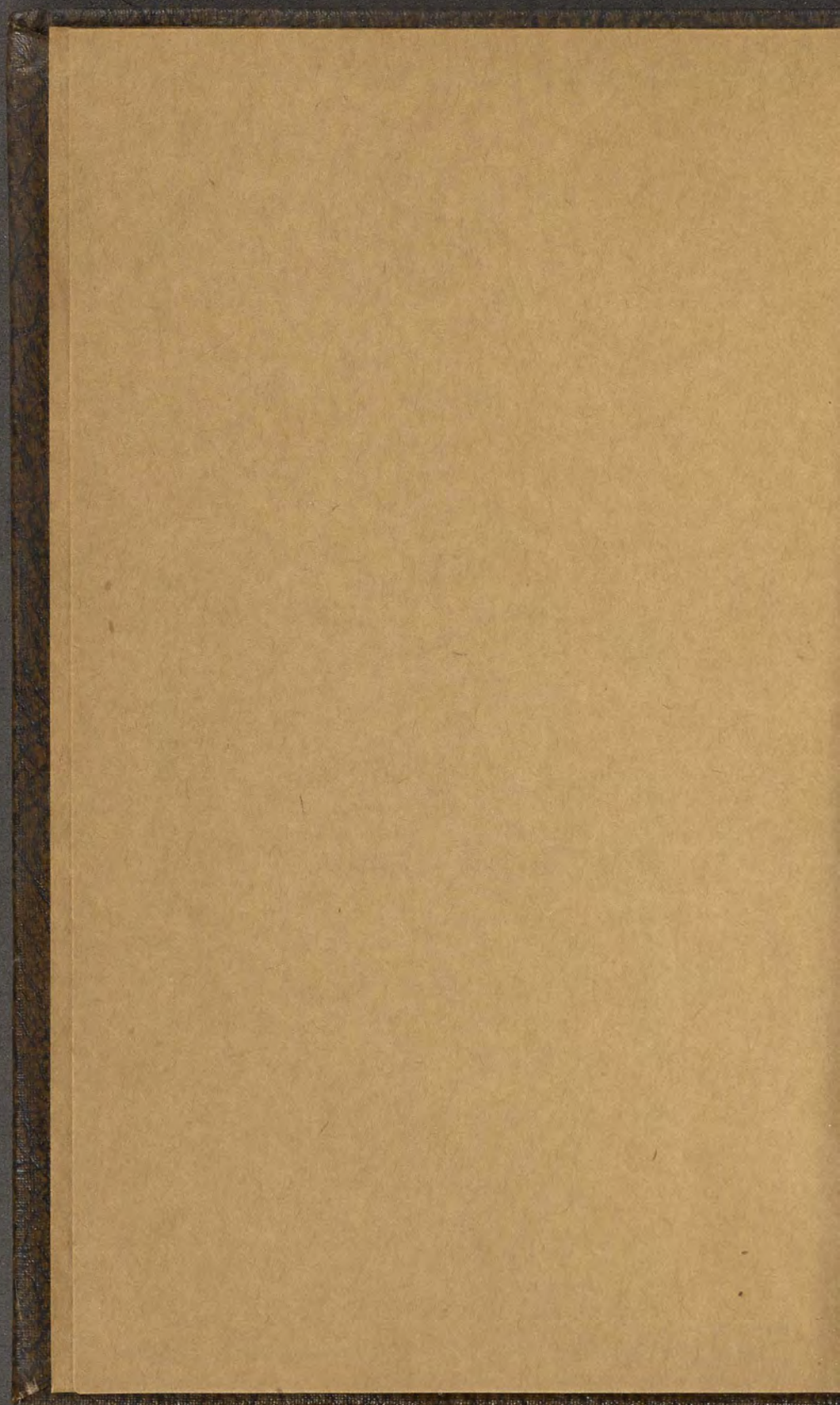
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ANALYTICAL ESSAYS  
TOWARDS PROMOTING  
THE  
CHEMICAL KNOWLEDGE  
OF  
MINERAL SUBSTANCES.

~~FRANKLIN INSTITUTE~~

BY MARTIN HENRY KLAPROTH, *of Berlin*

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TRANSLATED FROM THE GERMAN.

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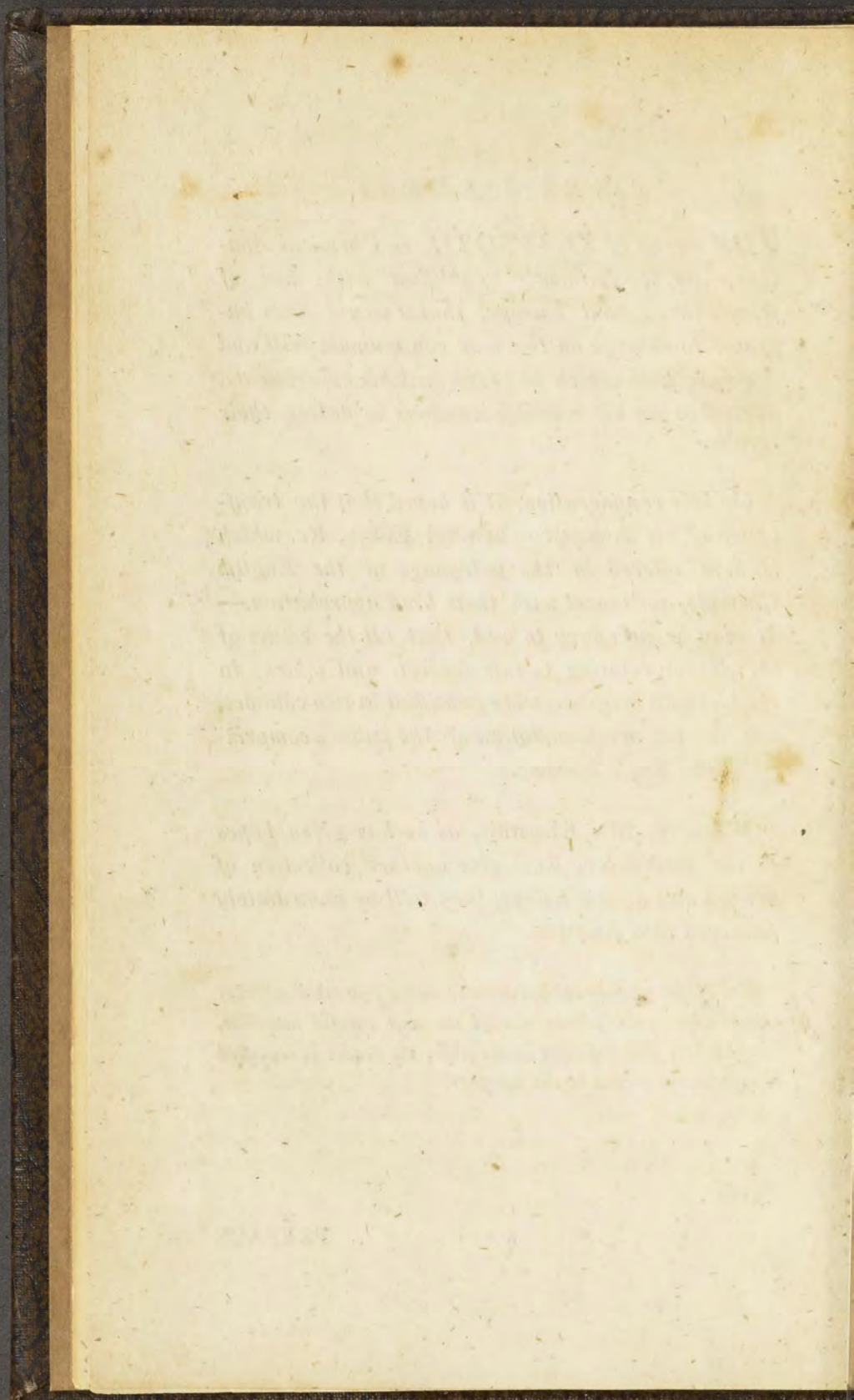
## ADVERTISEMENT.

*THE merits of KLAPROTH, in Chemical Analysis, are so eminently established with men of science throughout Europe, that it would seem improper to enlarge on the most consummate skill and accuracy with which he performed his experiments, as well as on his laudable candour in stating their results.*

*On this consideration, it is hoped that the translation of his Analytico-chemical Essays, &c. which is here offered to the patronage of the English Chemists, will meet with their kind approbation.— It may be necessary to add, that all the Essays of the Author relating to this subject, and which, in the German original, were published in two volumes, are, for the accommodation of the public, comprized in this single Volume.*

*Whenever Mr. Klaproth, as he has given hopes to the Translator, shall give another collection of his last and newest Essays, they will be immediately rendered into English.*

*✍ If some typographical errors, and a few other mistakes which unfortunately have escaped the most careful attention, should create some difficulty in the sense, the reader is requested to refer to the errata in the last page.*





PREFACE  
OF  
THE AUTHOR.

IT has long been my design to collect my *Mineralogico-chemical Essays*, dispersed in various books and journals, and to publish them, together with some new Researches; but want of time, and other impediments, have hitherto prevented me from accomplishing it.

Much as I wished to give to my Analytical Inquiries the greatest possible degree of truth and perfection, and thereby to fulfil the duties which the Chemist owes to the Science which he intends to promote by his writings, as well as to the Public, to whom he offers the fruits of his labour; I was, nevertheless, too often under the necessity of experiencing, how difficult it is to accomplish this purpose.

Of the 26 Treatises contained in this *first Vol. of Essays towards a Chemical Knowledge of Mineral Substances\**, the greater number is here published

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\* Mr. Klaproth here alludes to the publication of the first part of his *Essays*, at Berlin, 1795. The present volume comprehends also the second part of them; and what is said by the author, with respect to this last, has been added at the end of this Preface.—  
Transl.

for the first time. Each of them being unconnected with the others, I followed no particular order with them; and I also disregarded the order of publication, with respect to those that were before published separately. In my operations with the genus of *silver-ores*, I intended, for the farther advancement of the systematical part of *Oryctognosy*, to subject to analytical examination, not only particular species and varieties, but entire genuses, with their chief species. But I was soon convinced, that the execution of this design was impracticable, both on account of the few leisure hours which I could command, and as, in general, it surpasses the powers of an individual.

Having merely in view the progress of Natural Science, founded on *pure experience*, that is to say, on plain facts, free from all hypothesis, I entertain, on presenting these labours to the Public, the most ardent desire of seeing the words of Bergmann\*, "*Aliorum tentamina, presertim cardinalia, candide sunt revidenda*," put into practice; for, as this philosophical Chemist very properly adds: "*Plus vident oculi, quam oculus; ideoque, quæ nova exhibentur, pluribus testibus in diversis locis utiliter confirmari puto*."—Being thoroughly convinced of my own fallibility, I recommend this examination with the greater

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\* De Indagando Vero.



eagerness, since the results of several of my experiments, respecting the constituent parts of fossils, are, frequently, in striking contradiction to those given by others. Thus the mineralogical world may be informed, on which side truth stands, or the least error occurs; and the *Oryctologist* may, with greater certainty than before could be done, apply the data given him to the perfection of his art. On my part, I shall always receive with pleasure any well grounded correction of my labours, and better information.

With respect to those, who may possess patience and inclination sufficient to undertake a repetition of my experiments, I have described every particular management, as circumstantially as could be done, consistently with keeping within due bounds that prolixity which is hardly ever separable from the narrative of chemical processes. Those who are familiar with this subject, will perceive my endeavours to reduce the analysis of mineral bodies to methods which are simple in themselves, and lead to results that may be depended on. Among others, I flatter myself with having traced out a way of analysing *gems*, which seems to deserve being followed by skilful Chemists.

A circumstance, seemingly indifferent, often produces in chemical experiments, as in other investigations, unexpected consequences; which may be

proved by comparing my former with my later analytical experiments, made with the *Adamantine Spar*, and *Circon* (Jargon of Ceylon), which, on this account, I have placed next to each other in the respective Treatises. Who, for example, would have imagined, that the application of caustic alkali in the *liquid* state should so exceedingly facilitate the opening of hard stony matter, and remove the greatest part of the difficulties with which I had to struggle, when employing the same separating medium in the *dry* state?

As many persons think that the preparation of a perfectly pure caustic lye is subject to more difficulties than it really is, I will here briefly state my method of preparing it.—I boil equal parts of purified salt of tartar, (carbonat of potash, or vegetable alkali prepared from tartar) and Carrara marble, burnt to lime, with a sufficient quantity of water, in a polished iron kettle; I strain the lye through clean linen, and, though yet turbid, reduce it by boiling, till it contain about one half of its weight of caustic alkali; after which I pass it once more through a linen-cloth, and set it by in a glass bottle. After some days, when the lye has become clear of itself, by standing, I carefully pour it off from the sediment into another bottle. To convince myself of its purity, I saturate part of it with muriatic or nitric acid, evaporate it to dryness, and re-dissolve it in water.

If



If it be pure, no turbidness will take place in the solution. The quantity of caustic alkali, which this lye contains, I ascertain by evaporating a certain weighed portion of the lye to dryness, in an evaporating dish of a known weight. I also take care, in the preparation of this caustic lye, that the alkali be not entirely deprived of carbonic acid; because, in that case, I can, with greater certainty, depend on the total absence of dissolved calcareous earth. By employing burnt marble, or, in its stead, burnt oyster-shells, I avoid the usual contamination of the caustic lye by aluminous earth; because lime, prepared from the common species of lime-stone, is seldom entirely free from argil.

Besides, the choice of the vessels requires great care. Since even the best porcelain is attacked and dissolved by caustic alkali, I employ silver, reduced from muriat of silver, (Horn-silver), for vessels appropriated to fusion. This material, however, notwithstanding its other advantages, is not absolutely free from all inconvenience. For, if the crucible made of it has not been prepared with every possible care, small scales will detach from it, which mingle with the body to be examined, and frequently occasion illusive appearances. Having already found, unexpectedly, that even a crucible made of platina would not, as had been wished, resist the action of ignited caustic alkali; I imagine that a crucible made of pure massive gold would

be the most eligible. On this account, Professor *Storr* seems to be in the right, when he concludes his *Proposals, respecting the examination of the mixture of gems\**, with the following words: "The difficulties occurring in this operation will the sooner disappear, if a great amateur of gems should choose to spend the value of some thousand ducats for their examination." Meanwhile, I flatter myself with having in some manner counteracted those difficulties; though I was not encouraged by such a high premium.

Though for the most part I have followed the *new nomenclature*, I have not scrupulously confined myself to its terms; but have, for the sake of brevity, now and then used the denominations, *Glauber's-salt*, *Common-salt*, *Horn-silver*, *Blood-lye*, &c. as also the term *mild*, in stead of carbonated, in opposition to *caustic*†. Speaking of water, to avoid too frequent repetitions, I have mostly omitted to particularize it as *distilled*. Thus, also, I have not in every single instance mentioned the *edulcoration* of the precipitates, or residues; this and similar operations being always understood to have been performed.

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\* *Crell's Chemisches Journal*, vol. VI. 1781. page 227.

† The Translator, however, has, for the most part, preferred the *new nomenclature*, and frequently added the former denominations, for reasons not necessary to be particularly mentioned.—Transl.



*Concerning the Second Part.\**

I HERE offer to the chemical and mineralogical public the *second* volume of my *Essays*, &c. animated by the hope, that it will meet the same encouraging approbation with which the *first* has been honoured by scientific men, whose decision in this branch of the Knowledge of Nature commands respect.

The numbers of the *Essays*, contained in this volume, proceed in a continued series with those of the preceding. Of those now given (1797), only a few have been before printed in various publications, and are here merely collected.—All the others are entirely new, and, at present, published for the first time.

As these essays were the fruit of my leisure hours only, several of them have not arrived at that degree of perfection, to which, perhaps, they might

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\* This is the Preface to Mr. *Klaproth's* second volume of the German Edition; and the words, PART I. and PART II. have been designedly inserted in the following Table of CONTENTS; the better to distinguish the first 26 *Essays* belonging to the first volume from the remaining essays, published in the second volume of the original.

have approached, if the usual avocations of my duties had permitted me to perform them with greater convenience and opportunity.

In this respect I earnestly wish, that, for the advancement of the science, the *chemico-analytical researches* published in this second volume may share the same good fortune with those of the first:—I mean to say, that they may be examined, corrected, and farther pursued by expert Chemists.

M. H. KLAPROTH.

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CONTENTS.



# CONTENTS.

## PART I.

	Page
I. EXPERIMENTS concerning the Habitudes of various Species of <i>Stones</i> and <i>Earths</i> in the Heat of a <i>Porcelain-furnace</i> . . . . .	I
II. Analysis of the <i>black-grey Flint</i> . . . . .	39
III. Experiments on the <i>Adamantine Spar</i>	
<i>First Section</i> . . . . .	43
<i>Second Section</i> . . . . .	59
A. <i>Adamantine Spar</i> , from <i>China</i> . . . . .	60
B. ————— <i>Bengal</i> . . . . .	64
IV. Examination of the <i>Oriental Sapphire</i> . . . . .	71
V. Examination of the <i>Cat's-eye</i> . . . . .	78
A. From <i>Ceylon</i> . . . . .	79
B. ——— the <i>Coast of Malabar</i> . . . . .	82
VI. Analysis of <i>Chrysoberyl</i> . . . . .	85
VII. Examination of <i>Chrysolite</i> . . . . .	91
VIII. Examination of <i>Olivin</i> . . . . .	99
<i>First Section</i> . <i>Olivin</i> , from <i>Unckel</i> . . . . .	100
<i>Second Section</i> . ————— <i>Karlsberg</i> . . . . .	105
IX. Examination of various <i>Silver-ores</i> . . . . .	109
<i>First Section</i> . <i>Native Hornsilver</i> . . . . .	111
A. <i>Massive</i> , from <i>Saxony</i> . . . . .	115
B. <i>Corneous Silver-ore</i> , from <i>Schlangenberg</i> . . . . .	119
C. <i>Argillo-muriated Silver-ore</i> . . . . .	ib.
D. Of <i>Justi's</i> supposed <i>alkaline Silver-ore</i> . . . . .	121
<i>Second Section</i> . <i>Red Silver-ore</i> . . . . .	124
A. From <i>Andreasberg</i> , in the <i>Upper Harz</i> . . . . .	127
B. ——— <i>Freiberg</i> , in <i>Saxony</i> . . . . .	134
<i>Third Section</i> . <i>Vitreous Silver-ore</i> . . . . .	137
A. From <i>Freiberg</i> . . . . .	138
B. ——— <i>Joachimsthal</i> , in <i>Bohemia</i> . . . . .	139
<i>Fourth Section</i> . <i>Brittle vitreous Silver-ore</i> . . . . .	140
<i>Fifth Section</i> . <i>White Silver-ore</i> . . . . .	143
A. <i>Light-ditto</i> , from <i>Erbisdorf</i> , near <i>Freiberg</i> . . . . .	145
B. <i>Dark-ditto</i> , from <i>Freiberg</i> . . . . .	149
<i>Sixth Section</i> . <i>Grey Silver-ore</i> , from <i>Kremnitz</i> . . . . .	152
<i>Seventh Section</i> . <i>Native Amalgam of Silver</i> . . . . .	156
<i>Eighth Section</i> . <i>Arsenical Silver</i> , from <i>Andreasberg</i> . . . . .	158
X. Examination of the <i>Oriental Lapis Lazuli</i> . . . . .	163
	XI.

	Page
XI. Examination of the Smalt-blue Fossil, from <i>Vorau</i> , in <i>Austria</i> . . . . .	170
XII. Examination of the Jargon of Ceylon ( <i>Circon</i> ) <i>First Section</i> . . . . .	175
<i>Second Section</i> . . . . .	188
XIII. Examination of Hyacinth . . . . .	195
XIV. Examination of the <i>supposed</i> Hungarian Red Shörl . . . . .	200
XV. Examination of a new Fossil, from Passau . . . . .	211
XVI. Examination of the <i>supposed</i> Molybdenous Silver . . . . .	218
XVII. Examination of the Native Alumine, from <i>Schemnitz</i> . . . . .	221
XVIII. Chemical Researches into Strontianite compared with Witherite . . . . .	223
XIX. Examination of Lepidolite . . . . .	238
XX. Examination of Cimolite . . . . .	248
XXI. Examination of the Magnesian Spar A. From Tyrol . . . . .	256
B. From <i>Taberg</i> , in <i>Sweden</i> . . . . .	259
XXII. Examination of the <i>supposed</i> Muriacite . . . . .	262
XXIII. Examination of the Native Alum, from <i>Miseno</i> . . . . .	266
XXIV. Examination of the Native Nitre, from <i>Molfetta</i> . . . . .	270
XXV. Examination of the Mineral Springs at <i>Carlsbad</i> , in <i>Bohemia</i> . . . . .	274
XXVI. Examination of the Saline Springs at <i>Königsborn</i> , and their Products . . . . .	298

---

## PART II.

XXVII. EXAMINATION of Spinell . . . . .	316
XXVIII. Examination of the Emerald, from <i>Peru</i> . . . . .	325
XXIX. Examination of the Bohemian Garnet . . . . .	329
XXX. Examination of the Oriental Garnet . . . . .	334
XXXI. Examination of Vesuvian <i>First Section.</i> Vesuvian, from <i>Vesuvius</i> . . . . .	338
<i>Second Section.</i> ————— <i>Siberia</i> . . . . .	342
XXXII. Examination of Leucite <i>First Section.</i> Leucite, from <i>Vesuvius</i> . . . . .	348
<i>Second Section.</i> The same continued . . . . .	352
<i>Third Section.</i> Leucite, from <i>Albano</i> . . . . .	361
<i>Fourth Section.</i> ————— in irregular masses . . . . .	363
<i>Fifth Section.</i> ————— acted on by volcanic fire 1. From <i>Pompeji</i> . . . . .	364
2. ——— <i>Ronciglione</i> . . . . .	365
XXXIV.	



# CONTENTS.

xv

	Page
XXXIII. Examination of Pumice-stone, from Lipari . . .	368
XXXIV. Examination of the Terra Australis ( <i>Sidneia</i> ) . . .	371
XXXV. Examination of the granular Sulphat of Barytes, from Peggau . . . . .	375
XXXVI. Examination of the testaceous Sulphat of Barytes, from Freiberg . . . . .	378
XXXVII. Examination of Staurolite ( <i>Cross-stone</i> ) . . .	384
XXXVIII. Farther Researches into Witherite and Strontianite	
<i>First Section</i> . . . . .	387
<i>Second Section</i> . . . . .	390
XXXIX. Examination of the Sulphat of Strontian, from Pennsylvania . . . . .	394
XL. Examination of the Water of the Boiling Spring, at Rykum, in Iceland . . . . .	399
XLI. Examination of the siliceous Tufa ( <i>Kieseltuff</i> ) from the Geyser, in Iceland . . . . .	406
XLII. Examination of the Elastic Quarz, from Brasil . . .	409
XLIII. Examination of the Hyalite (Glass-stone), from Dauphiny . . . . .	413
XLIV. Examination of Chrysoprase, and its concomitant green Earth	
<i>First Section.</i> Analysis of Chrysoprase . . . . .	420
<i>Second Section.</i> Analysis of the green Earth of Chrysoprase . . . . .	425
XLV. Examination of the Noble Opal, from Cscherwenitzza, in Upper Hungary . . . . .	440
XLVI. Examination of the Hydrophanes, from Saxony . . .	443
XLVII. Examination of the White and Green Opal, from Kosemütz, in Silesia . . . . .	445
XLVIII. Examination of the Yellow Opal, from Telkebanya, in Upper-Hungary . . . . .	447
XLIX. Examination of the Brown-red Semi-opal, from Telkebanya, in Hungary . . . . .	449
L. Examination of Menilite, from Menil-montant, near Paris . . . . .	451
LI. Examination of Werner's Polishing-slate, from Menil-montant, near Paris . . . . .	455
LII. Examination of Silici-murite (Meerschaum), from the Levant . . . . .	456
LIII. Examination of the Semi-indurated Steatites, from Bareuth, in Franconia . . . . .	460
LIV. Examination of Steatites (Soap-rock), from Cornwall . . . . .	462
LV. Examination of the Chinese Agalmatolite (Plastic-stone) . . . . .	465
	LVI.

	Page
LVI. Second Examination of <i>Lepidolite</i> (page 238) . . .	471
LVII. Examination of <i>Uranite</i> . . . . .	476
LVIII. Examination of <i>two</i> newly discovered <i>Titanites</i> , from <i>Spain</i> , and <i>Aschaffenburg</i> , in <i>Germany</i> . . .	496
LIX. Examination of some <i>ferruginous Titanites</i> , from <i>Cornwall</i> . . . . .	499
LX. Examination of the <i>Garnet-shaped Ore of Manganese</i> , from the <i>Spessart</i> . . . . .	510
LXI. Examination of the <i>Native Oxyd of Tin</i> ( <i>Tin-stone</i> ) . . .	515
LXII. Examination of the <i>Native Sulphuret of Tin</i> ( <i>Tin-pyrites</i> ), from <i>Cornwall</i> . . . . .	525
LXIII. Examination of the <i>Molybdat of Lead</i> , from <i>Blei-berg</i> , in <i>Carinthia</i> . . . . .	532
LXIV. Examination of the <i>Sulphuret of Copper</i> ( <i>vitreous</i> <i>Copper-ore</i> , <i>Kupfer-glanz</i> ), from <i>Siberia</i> . . .	541
LXV. Examination of the <i>variegated Copper-ores</i> ( <i>Buntkupfererz</i> ) from <i>Hitterdahl</i> , in <i>Norway</i> , and <i>Rudelsdorf</i> , in <i>Silesia</i> . . . . .	545
LXVI. Examination of the <i>Siberian Malachites</i> . . . . .	550
LXVII. Examination of the <i>Bismuthic Silver-ore</i> , from <i>Schapbach</i> , in <i>Suabia</i> . . . . .	554
LXVIII. Examination of the <i>Antimoniated Silver</i> , from <i>Wolfach</i> , in <i>Suabia</i> . . . . .	560
LXIX. Examination of the <i>crystallized, bright, white, Cobalt-ore</i> ( <i>Glanz-kobalt</i> ), from <i>Tunaberg</i> , in <i>Sweden</i> . . .	564
LXX. Examination of the <i>Cobaltic Ore of Manganese</i> , from <i>Rengersdorf</i> , in <i>Lusatia</i> . . . . .	569
LXXI. Examination of the <i>Native Sulphat of Cobalt</i> ( <i>Kobalt-vitriol</i> ) from <i>Herrengrund</i> , in <i>Hungary</i> . . . . .	579
LXXII. Examination of the <i>Mineral Springs</i> at <i>Imnau</i> , in <i>Suabia</i> . . . . .	580



# I.

## EXPERIMENTS

ON THE

HABITUDES OF VARIOUS SPECIES

OF

STONES AND EARTHS

IN THE

FIRE OF A PORCELAIN-FURNACE.

~~~~~

A SCIENTIFIC enquiry into that class of natural bodies, which belong to the *mineral kingdom*, includes a number of particulars, which it is necessary to unite, in order to obtain a complete knowledge of the subject.

These are:

1. Their *geognostic* situation\*: and
2. Their *external characteristic marks*: which both together constitute their *natural history*.
3. The experiments relating to the *physical properties* and powers of bodies in an undecomposed state. Such are: their specific gravity, elasticity, magnetic attraction, the phenomena exhibited by them with regard to light, and the like.
4. Their habits or changes in the *fire*; and
5. Their *chemical constituent parts*.

---

\* *Werner*, who introduced the expression *Geognosy*, understands by it a general acquaintance with the solid parts of our globe, the various situations or beds of fossils, and their reciprocal relations to each other. Thus he distinguishes *geognosy* from *mineralogical geography*, which only treats of the native places of fossils.—Transl.

## 2 I. *Habitudes of Stones and Earths*

As to the *habitudes of minerals in fire*, they indeed belong to the *chemical* part of natural science; but so far only, as their constituent parts, or their proportions to each other, are made to suffer an alteration by this agent. Therefore, the phenomena, which take place on warming or heating, without producing a lasting change in the chemical mixture of the constituent parts, do not belong to this, but to its *physical* part. Thus, for instance, the power of attracting and repelling light bodies, excited in *Tourmaline* by warming it, should only be reckoned among its physical properties; but, on the contrary, the phosphorescence of the *Fluor-spar* and the *Apatite*, though but moderately heated, already effect some alteration in the natural chemical proportion of their constituent parts.

Though several industrious naturalists have examined various species of earths and stones merely by fire, few of them, however, have furnished *simple facts* or *experiments*. Some, as *Pott* and *Gellert*, according to their particular purposes, have directed their attention more to the products of fusion, in compositions of their own making, than to the mere *habitudes* of the simple fossils. Others, *D'Arcet* for instance, have indeed had regard to this last circumstance; but they have missed their end, at least for the greatest part, by exposing the body under trial to fire in immediate contact with argillaceous crucibles. For, the results could not fail to be false in most cases, on account of the aluminous earth from the corroded mass of the crucible mingling with the substance of the experiment.

So far as I know, Mr. *Gerhard*\* is the only chemist, who, in his valuable experiments concerning the *habi-*

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\* *Gerhard's Versuch einer Geschichte des Mineralreichs*, 2 Vol. Berlin, 1781-82.—Vol. II. § 2. page 3—44.



tudes of fossils in the fire, has paid due attention to the nature of the vessels; and has communicated true results, because in his operations he employed crucibles of charcoal, besides those manufactured of clay and chalk.

The results of my experiments on the effects produced by fire on various species of stones and earths, which I am now about to give, may serve to confirm several, and in some respects be considered as a continuation of those of *Gerhard*.

When speaking of the experiments on fusion made by the above mentioned naturalists, as well as of my own, the mere action of *common* fire in wind and porcelain-furnaces is understood. Hence, neither dioptrical and catoptrical experiments belong to this investigation; nor those, which several philosophers have made by strengthening the fire by means of oxygen gas. For, howsoever valuable the latter are in other respects, I am inclined to think, that in a mineralogical view, the action of violent ignition sustained by oxygen gas is not a convenient method for ascertaining the relative habitudes of minerals in the fire.

To be enabled to draw just conclusions from experiments of this kind, it is necessary that they be all performed with the most equal degree of heat. This advantage was afforded to me by the furnaces of the Royal Porcelain-manufactory (at Berlin); into which the fossils, ready prepared for this trial, were put; together with the porcelain, subjected to final baking.

For experiments to be performed in charcoal crucibles, a cavity was made in a thick fragment of well-burned charcoal, of a volume answering the size of the fossil. This being put in, the cavity was closed with a charcoal stopper; after

4 I. *Habitudes of Stones and Earths*

after which the charcoal-crucible was fitted into another crucible made of baked clay, and this last well joined with its cover by luting.

In order to make comparative experiments, I placed another quantity of each fossil immediately in a crucible made of clay unmixed with iron. After the cover had been luted on, it was exposed to the same intensity of heat.

In every case where the loss of weight could be ascertained with some degree of certainty, I have always mentioned it.

---

No. I. ADULARIA; from Mount St. Gotthard.

a) In the *charcoal-crucible*\*, a colourless glass, clear in its substance, but quite full of very small froth-bubbles. On this account it appears of a greyish-white, and exhibits no vitreous splintery fracture, but a minute conchoidal, with very fine pores.

b) In the *clay-crucible*. The same.

No. 2. White ALABASTER.

a) CH. Cr. was rendered moderately hard, white passing into straw-yellow, in some places finely streaked, of a fine-grained earthy fracture, adhering to the tongue, and emitting an odour like that of alkaline sulphuret.—Loss of weight, 0,56.

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\* For the sake of brevity, the *Charcoal-crucible* is marked CH. Cr. and the *Clay-crucible*, CL. Cr.

In the same manner L. of W. means *loss of weight*.



b) CL. Cr. A black-brown glass, very shining, little transparent on the edges, with separate bubbles.

No. 3. AMIANTHUS; from *Greenland*.

a) CH. Cr. A roundish fused scoria, of a dirty pearl grey, externally covered with some small grains of iron. Fracture, dull, finely porous, with dispersed inlaid glossy particles.

b) CL. Cr. Has run into a greenish, opaque scoria, of a fracture almost dull. The whole surface covered with crystals of a greenish and light brown colour, in the form of delicate needles, of a reticular form.

No. 4. ASBESTUS, mountain green: (Berg-holz) from *Siberia*.

a) CH. Cr. Unaltered as to form, simply hardened by ignition. Its surface invested with a thin reddish crust; the edges blackish, and overlaid with fine exsuded grains of iron.—L. of W. 0,16.

b) CL. Cr. The form likewise unchanged; of a light-brown colour, rendered very hard, and covered with some ferruginous spots.

No. 5. ASBESTUS; from *Taberg*.

a) CH. Cr. A light-grey slag, fused into a sphere, and covered with grains of iron, of a glittering surface, and having detached, shining, large bubble-holes.—L. of W. 0,25.

N. 6. BASALT; ash-grey, coarse-grained. (Swed. *Trap*; and, according to *Werner*, Grünstein;) from *Hünneberg*, in *Westgothland*.

a) CH. Cr. Fused into a compact glass, of a clove-brown colour, transparent in splinters, of a large con-

choidal fracture. Externally, partly glazed brown, partly invested with a ferruginous crust, and large grains of iron.—L. of W. 0,06.

b) A solid black glass, covered with a brown, steel-grey, veined iron-crust.

No. 7. BASALT, dense, columnar; from the *Hafenberge*, in the middle mountains of Bohemia.

a) CH. Cr. Externally, a compact grey mass, richly over-laid with pretty large grains of iron, and in part also covered with a tombac-brown ferruginous crust. Its fracture of a bright ash-grey, and to appearance dull and earthy; but if examined with a lens, possessed of a texture very finely porous, and spongy throughout; and very rough to the feel.—L. of W. 0,09.

b) CL. Cr. A black dense glass, transparent, and of a clove-brown, in thin splinters, of an even or gross-conchoidal fracture. At the top, it exhibits a light-brown, glossy, and delicately-flowered crust.

No. 8. BASALT, dense, columnar; from *Stolpe*, in Saxony.

a) CH. Cr. A compact mass, invested at the top with a blackish grey glazing, but, on the sides and underneath, with numerous grains of iron, and in part covered with a tombac-brown iron-crust. In fracture, ash-grey, dull, dense, somewhat splintery, in some places of a spongy texture hardly distinguishable, and in others exhibiting clove-brown glossy veins.—L. of W. 0,08.

*Note 1.* Another, but smaller quantity of the same basalt, treated in the same manner, I found, had the same external appearances; but its internal colour was white-grey; its texture was more dense, and traversed by minute, blackish vitreous veins.

*Note*



*Note 2.* I put the specimen of No. 8. *a*) a second time into the charcoal crucible, after having separated the iron-grains. It appeared afterwards of an amorphous, and on the upper part confusedly fibrous form; but its fracture presented a darkish grey, compact, fine-grained, untransparent, highly glittering, and, towards the sides, greasy glossy scoria.

*b*) CL. Cr. As No. 7. *b*).

No. 9. BASALT, largely perforated, with interspersed, single, small grains of olivin; from the island of *Skye*.

*a*) CH. Cr. On the surface overlaid with many grains of iron, of a considerable size. Fracture dark ash-grey, very rugged, dull, and earthy; but, viewed by a lens, spongy, with fine pores.—L. of W. 0,08.

*Note.* The grains of iron being separated, this mass was again placed in a fresh CH. Cr. Its surface then assumed the figure of vermicularly twisted branches, lying flat; some of which had a copper-red metallic lustre. Its fracture like No. 8, note 2.

*b*) CL. Cr. The same as No. 7. *b*)

No. 10. BASALT, porphyraceous; from the new *Cammeni*, near *Santorini*.

*Note.* The principal black mass was a medium between siliceous schist, (*Kiefelschiefer*) Jasper, and basalt; with disseminated tender, white, vitreous squares and grains.

*a*) CH. Cr. Melted into a solid, blackish glass; whose fragments were of a yellowish-green, and transparent. It was covered with a steel-grey ferruginous crust, and of a glossy, large conchoidal fracture.—L. of W. 0,02.

*b*) CL. Cr. A compact, black glass; but its splinters clove-brown and transparent. Fracture of the large, and, in some degree, smooth conchoidal form. Surface invested with a bright brown, shining pellicle.

No. 11. LIGNIFORM ASBESTUS (Bergholz), brown;  
from *Tyrol*.

a) CH. Cr. Suffered no alteration of form; burned hard, and assumed a greenish-brown surface, with a red and white investment. Its edges foliated in lamellæ, blackish, and garnished with extremely delicate exuded grains of iron. Fracture bright, steel-grey, and glittering.—L. of W. 0,39.

b) CL. Cr. Coalescing by fusion with the parts of the crucibles that were in contact with the fragments. Their external surfaces exhibited a texture, consisting of brown, resplendent, implicated, short striæ. The fracture dark-grey, little shining, and of bright-grey rays and points, as it were interwoven, with some air-bubbles.

No. 12. BERYL, yellow; from *Siberia*.

a) CH. Cr. No change in the figure. Colour dirty pale-bluish-grey, with a greasy lustre, and a little transparent. Fracture uneven, gross-splintery.—L. of W. 0,01.

b) CL. Cr. The same.

No. 13. BERYL, sea-green; also from *Siberia*.

a) CH. Cr. In general of less splendour; but the lateral surfaces of the column covered all over with fine, shining, needle-formed radii. In other respects, as No. 12. a)

b) CL. Cr. Like No. 12. b)

No. 14. SHORLITE (*Schörlartiger Beryl*); from *Altenberg*.

a) CH. Cr. Unaltered as to form; indurated by the ignition; became grey, dull, and rough; with minute glittering points of a nearly metallic lustre.—L. of W. 0,25.

b) CL. Cr. The same phenomena; but without shining points.

No.



No. 15. PUMICE-STONE, common; from *Lipari*.

a) CH. Cr. A bluish-black-grey, dense glass, with some air-bubbles; semi-translucent when reduced to thin fragments; and externally overlaid with a few grains of iron. L. of W. 0,10.

b) CL. Cr. Afforded a clearly fused, light-blackish-green, glassy substance, of almost colourless and clear splinters, with some air-bubbles.

No. 16. COMPOUND SPAR (*Bitterspath*); from *Zillertal*, in *Tyrol*.

a) CH. Cr. Fell into small yellowish-grey, and yellowish-brown, friable, and in part distinctly rhomboidal pieces, of an earthy appearance.—L. of W. 0,45.

b) CL. Cr. On the upper part it run into a clear, bright grass-green glass, of a smooth surface; but on the lower part into a light-grey frothy scoria.

No. 17. BOLE, red armenian; *genuine*.

*Note.* Consists of a red, friable lithomarga (*Steinmark*), with white speckles.

a) CH. Cr. Burned hard, was glittering, and of an iron-black colour.—L. of W. 0,20.

b) CL. Cr. Hardened by burning; partly steel-grey, partly dirty-brown; having the surface covered with transfused and re-calcined or oxyded ferruginous particles; rough and porous.

No. 18. BOLE, red armenian; *common*.

a) Melted into an ill-shaped hollow globe, whose outward and inward surfaces were of a dim steel-grey colour,  
and

10 I. *Habitudes of Stones and Earths*

and inlaid with resplendent grains of iron. Its fracture presented a black-grey slag, shining, and in part porous.—  
L. of W. 0,16.

b) CL. Cr. Gave a brown scoria; glossy like pitch; full of large bubbles; of an uneven surface, resembling the specular or grey iron-ore (*eisen-glänzig*).

No. 19. BORACITE; from *Lüneburg*.

a) CH. Cr. Each crystal fell separately into a globular form; acquired a cavity in the middle, and presented here and there incumbent, very tender ferruginous grains. Fracture whitish-grey, shining, uneven, and foliated; in part also striated.

b) CL. Cr. Produced a yellowish, clear glass, containing some air-bubbles; and having separate, small, dim-white spots.

No. 20. SIDERO-CALCITE (*Braunspath*), in lumps\*, grey-white; from *Freyberg*.

a) CH. Cr. Fell into black-brown, cracked and friable lumps, entirely resembling perfectly decayed sidero-calcite, and shewed exceedingly minute, transfused metallic grains.

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\* In German *derbe*, the precise meaning of which expression *Kirwan* asserts, (*Elem. of Mineral*. I. p 26) he could never learn. According to *Emmerling*, any solid fossil is called *derbe* which is concreted or imbedded in another, and is of the size of a *hazelnut*, and above, to any magnitude; whereas that which is called in German *cingesprengt* (disseminated, interspersed) is under the size of a hazel-nut, to any minuteness observable. As the size of the fossils treated of in this work is seldom determined, the word *derbe* will be given in this translation by the expressions *in lumps*, *in mass*, and sometimes *massive*.—Transl.

b) CL.



b) CL. Cr. Changed into a glass of a dark black-brown colour, transparent on the edges, and pellucid in small fragments.

No. 21. CORNELIAN, oriental.

a) CH. Cr. No change in its form, very fragile, of a snowy-white from the outer edge, almost to the thickness of  $\frac{1}{12}$  inch; but internally very pale reddish white. The fracture of the white border was conchoidal and resplendent; that of the inner parts earthy and dull.—It suffered no loss of weight.

b) CL. Cr. Throughout of a snow-white, partly spotted, somewhat greyish, and preserving its external splendour.

No. 22. CHALCEDONY; from *Ferröe*.

a) CH. Cr. Of unaltered shape; white as snow; easy to be broken; externally, and in the fracture, glittering.—L. of W. 0,01.

b) CL. Cr. The same.

No. 23. CHLORITE, loose, from the cavity of a rock-crystal; from *St. Gotthard*.

a) CH. Cr. A contracted, black, shining, somewhat radiated mass, similar to a brittle pit-coal.

b) CL. Cr. Fused into a solid, black-brown, vitreous substance.

No. 24. CHRYSOBERYL, from *Brazil*.

a) CH. Cr. Remained totally unchanged, except that its surface became a little rougher.

b) CL. Cr. Likewise unaltered; only its colour turned somewhat paler, and the external surface acquired spots of a dull white.

No.

## No. 25. CHRYSOLITE, oriental.

a) CH. Cr. Its surface covered with a thick ferruginous crust, of a reddish-brown, passing into steel-grey, and glittering. Its original green colour was no longer perceivable in the fracture. Its form, splendour, and transparency, quite unaltered.

b) CL. Cr. No change as to form, transparency, and lustre; but the colour inclined now to olive-green.

No. 26. CHRYSOPRASE; from *Kosmütz*.

a) CH. Cr. Had its figure unaltered, turned very light blackish-grey, of a strong gloss, and perfectly opaque. In the streak it exhibited a kind of metallic lustre.—L. of W. 0,01.

b) CL. Cr. The same effect.

No. 27. CIMOLITE; from the island of *Cimolo* (Cimolia Plinii).

a) CH. Cr. A black-grey, moderately shining, scummy slag, of little weight.—L. of W. 0,25.

b) CL. Cr. A yellowish-white, half fused, hard, small frothy scoria, resembling corroded quartz.

No. 28. CYANITE, crystallized; from *St. Gotthard*.

a) CH. Cr. Burned white, was split, became very friable, and internally shining.—No loss of weight.

b) CL. Cr. The same.

## No. 29. CYANITE, common; from the same place.

a) CH. Cr. Was rendered ash-grey by ignition, and split, in the manner of wood.—No loss of weight.

b) CL. Cr. Snowy-white, and split.

No.



No. 30. FEL-SPAR? compact, blue; from *Krieglach*.

a) CH. Cr. Furnished a grey-white glass, scummy in the fracture, and thereby divided into shapeless cellules, like fine tabular quartz. It presented detached ferruginous grains, and shewed also on the surface a number of fine splendid speckles.—L. of W. 0,40.

b) CL. Cr. Shrunk into milky-white, irregular, rough lumps, with a distinctly beginning vitrification.

No. 31. FEL-SPAR, common, red; from *Lomnitz*.

a) CH. Cr. As No. 1. a)

b) CL. Cr. As No. 1. a)

No. 32. FEL-SPAR, vitreous, in hexagonal plates; from the *Porphyry* of *Drachenfels*.

a) CH. Cr. A greyish-white glass, almost pellucid; of a strong gloss on the fracture, and having air-bubbles.—L. of W. 0,02.

b) CL. Cr. A semi-pellucid, bright-grey, somewhat frothed glass; in some places speckled blackish or brownish.

No. 33. FEL-SPAR, green; from *Siberia*.

a) CH. Cr. Like No. 32. a)

b) CL. Cr. Produced a milk-white glass, of a fine froth, but clear in small pieces.

No. 34. FLUOR-SPAR, yellow, cubic; from *Gersdorf*.

a) CH. Cr. A milky-white scoria; fused on the outside; in the fracture lamellar, of resplendent planes.—L. of W. 0,04.

b) CL. Cr. Fused into a clear, bright grass-green glass.

No.

14 I. *Habitudes of Stones and Earths*

No. 35. SPECULAR GYPSUM (*Frauenis, glaciæ Mariæ.*)

a) CH. Cr. Rendered white, very friable; and its lamellæ specular or reflecting light.—L. of W. 0,60.

b) CL. Cr. Clove-brown glafs, with large spherical air-bubbles.

No. 36. HYALITE, or Glafs-stone, (VIOLET SHOERL); cryftallized; from *Dauphiny*.

a) CH. Cr. A semi-pellucid greyish-white glafs, brilliant, flat conchoidal fracture; outwardly spread over with ferruginous grains.—L. of W. 0,12.

b) CL. Cr. A dense, semi-pellucid, deep clove-brown.

No. 37. HYALITE (*Violet Shörl*), in maffes; from *Thum (Thumerstone)*.

a) CH. Cr. As No. 36. a).—L. of W. 0,10.

b) CL. Cr. As No. 36. b).

No. 38. MICA, grey, grofs-foliated; from *Cornwall*.

a) CH. Cr. A greenish-grey, semi-pellucid glafs, overlaid with minute grains of iron.—L. of W. 0,10.

b) CL. Cr. Run into a compact, blackish, opaque glafs; of a smooth, strongly-shining surface, and conchoidal fracture.

No. 39. GARNET, red, bohemian.

a) CH. Cr. Afforded a grey, turbid glafs; full of grains of iron.

b) CL. Cr. Fused into an opaque, almost compact scoria, whose colour internally changed by stripes from brown into green; very finely corroded.

No.



No. 40. GARNET, oriental.

a) CH. Cr. The same change as No. 39. a).

b) CL. Cr. Yielded a compact black glass; of a bright lustre; covered with a steel-grey crust.

No. 41. GRANATITE, (till now so called); from St. Gotthard.

a) CH. Cr. Became hard; steel-grey; overlaid with small ferruginous grains.

b) CL. Cr. Rendered hard; of an iron black colour; with shining points of a metallic lustre.

No. 42. GREEN EARTH; from Cyprus.

a) CH. Cr. Fused into an irregular sphere; which had externally a dirty green colour, and presented in the fracture a somewhat porous mass, composed of an emerald-green glass and a pale-green scoria. Here and there it was crossed partly by white metallic lamellæ, partly by reguline copper. There was also found, in one of its cavities, a variegated copper-ore in small grains.—L. of W. 0,17.

b) CL. Cr. Exhibited a fused compact scoria; in the fracture of which the upper part was brown and resplendent; the lower one greenish grey, and glittering. At top it shewed grey-white, delicate plumose traces, of a lustre nearly metallic, upon a brown ground.

No. 43. HELIOTROPIUM, oriental.

a) The figure unaltered; but rendered a little softer by the ignition. The colour changed from dull-greenish to a grey-white. Its fracture uneven, splintery, rough and glittering. The red points, which had disappeared, left small holes behind them.—L. of W. 0,01.

b) CL. Cr. The colour turned throughout whitish grey. In other respects as at a).

No. 44. HORN-BLENDE, basaltic; from the crater of *Vesuvius*.

a) CH. Cr. A hardened, ill-shaped mass, with grains of iron. Fracture light-grey, uneven, faintly glittering; without any trace of vitrification.—L. of W. 0,10.

b) CL. Cr. Melted into a dense, black-brown glass; transparent in thin fragments; of a smooth surface, and a flat conchoidal, glossy fracture.

No. 45. HORN BLENDE, common; from *Neurode*, in the county of *Glatz*, in Bohemia.

a) CH. Cr. An indurated mass; on the outside wrinkled, of a colour verging into copper-red, inlaid with many granular particles of iron. Internally light pearly-grey, uneven, slightly glittering; here and there with a beginning vitrification.—L. of W. 0,06.

b) CL. Cr. As No. 44. b).

No. 46. HORNLENDE? common; from *Nora*, in Westmanland.

a) CH. Cr. Run into an imperfect, greenish-black vitreous substance, transparent on the edges, overlaid with an iron black, rugose or shrivelled crust. Fracture, with air-bubbles, of a copper-colour.—L. of W. 0,14.

b) CL. Cr. A compact scoria, whose colour, from below upwards, changed from leek-green to greenish black. Covered with a steel-grey metallic crust. Fracture, moderately shining, of a greasy lustre.

No.



No. 47. HYACINTH; from *Ceylon*.

a) CH. Cr. Its colour became greyish-white. The crystals in some degree coalesced; but remained in other respects unchanged, except their transparency being diminished.—No. L. of W.

b) CL. Cr. Such of the crystals as were in contact with the crucible, united with it by fusion, throwing up a ferruginous crust. The others were loosely conglutinated together. The colour, in part, passed into a wine-yellow.

No. 48. CAT'S-EYES, grey-white; from *Ceylon*.

a) CH. Cr. Became soft, grey, dimmed, and opaque by the action of the fire.—No. L. of W.

b) CL. Cr. The same change.

No. 49. CAT'S-EYE, red; from *Malabar*.

a) CH. Cr. Like No. 48. a)

b) CL. Cr. The same.

No. 50. LABRADOR-HORNBLLENDE (*Labrador-*  
*stein*).

a) CH. Cr. Fused into a compact glass, of great lustre, pellucid in small splinters, of a pale-grey colour, with very minute, detached grains of iron.—L. of W. 0,04.

b) CL. Cr. A compact, dusky-white scoria, transparent on the edges.

## No. 51. LAPIS LAZULI, deep-blue.

a) CH. Cr. A dense, grey, semi-pellucid glass; overlaid with grains of iron.—L. of W. 0,12.

b) CL. Cr. A dense, brownish, black glass, with separate grains of iron upon its surface.

No. 52. LAVA, loose, frothy; from *Vesuvius*.

a) CH. Cr. Changed to a compact glass, of a greenish-grey tinge, containing granular particles of iron; and transparent on the edges.—L. of W. 0,08.

b) CL. Cr. A compact, brownish-black glass, having rusty spots on the upper part.

## No. 53. LEMNIAN EARTH, common. (Bole).

a) CH. Cr. A dense, deep-greenish-grey glass, covered with a crust coloured like rust of iron, and some ferruginous grains.—L. of W. 0,25.

b) CL. Cr. A compact greenish-black glass; shewing at the top light-brown points, lying flat.

No. 54. LEPIDOLITE (Lilalite); from *Rosna* in Moravia.

a) CH. Cr. Produced a pale-grey, dense, semi-pellucid, very hard glass; partially covered with a grey ferruginous crust.—L. of W. 0,17.

b) CL. Cr. Afforded a greyish-white, transparent glass, with very small bubbles; and on the upper parts covered with a light-brown crust, of a lustre nearly metallic.

No.



No. 55. LEUCITE (not yet affected by volcanic fire);  
from *Vesuvius*.

a) CH. Cr. Outwardly a commencement of fusion; the inside little altered, and still very glossy. The hornblende which it contained within, was melted into separate, black, minute drops.

b) CL. Cr. Exactly the same.

No. 56. MARBLE, white; from *Carrara*.

a) CH. Cr. Was converted into quicklime.

b) CL. Cr. Changed into a dense, clear, hard, pale grass-green glass.

No. 57. PLASTIC SILICI-MURITE (*Meerschauum*,  
*Keffekil* of Cronstedt); from the *Levant*.

a) CH. Cr. Not altered; only rendered more meagre and indurated by ignition; very strongly adhering to the tongue.—L. of W. 0,30.

b) CL. Cr. The same.

No. 58. OBSIDIAN, black; from Mount *Hecla* in  
Iceland.

a) CH. Cr. A greenish-black glass, of great splendour; pellucid in small pieces, outwardly with a grey incrustation.

b) CL. Cr. Melted into a dense, black-brown glass; transparent only in its smallest splinters, and of a conchoidal fracture.

No. 59. OBSIDIAN, blackish-grey, transparent ; from  
*Lipari.*

a) CH. Cr. Gave a glass, pellucid in larger lumps ; of a somewhat dusky, pale, grass-green hue, containing air-bubbles, and externally covered with a grey turbid crust.

b) CL. Cr. Fused into a clear, pale-black-greenish glass, with separate bubble-holes.

No. 60. OBSIDIAN ; from *Tokay.*

a) CH. Cr. Like No. 59. a)

b) CL. Cr. Like No. 59. b)

No. 61. OLIVIN ; from *Greenland.*

a) CH. Cr. The grains black, opaque, finely glazed, and conglutinated.

b) CL. Cr. Almost the same change, and coalesced with the sides of the crucible, which it powerfully attacked.

No. 62. OLIVIN ; from *Habichtswalde.*

(a CH. Cr. As No. 61. a) ; only a little more firmly coalesced.

b) CL. Cr. As No. 61. b)

No. 63. OLIVIN ; from *Rittersdorff*, in the middle mountains of Bohemia.

a) CH. Cr. The concretion of the grains stronger ; also strongly glazed, and of a dirty leek-green.

b) CL.



b) CL. Cr. Like No. 61. b)

No. 64. OLIVIN ; from *Unkel*.

a) CH. Cr. Its grains were covered with a greenish-black glaze, cemented together, and crossed by a white mass, in some places crystallized in a delicate capillary form. Their outer sides were invested with grains of iron.—L. of W. 0,02.

b) CL. Cr. Were fused into one glossy, somewhat porous mass, which, in the upper part, was crystallized in a radiated form, with a brownish-grey tinge ; but in the fracture it was partly greenish-white, partly grass-green.

No. 65. OPAL (semi-opal), brown-red ; from the *Telkebanya* mountains.

a) CH. Cr. Without alteration as to form. Externally black-grey, dull, and in every part covered with disseminated small grains of iron. In the fracture, brownish-grey, dull, and uneven.—L. of W. 0,18.

b) CL. Cr. Little changed in the form. Externally resembling the specular or grey iron-ore (*Eisenglanz*). Its fracture black, glittering, and in a small degree porous.

No. 66. OPAL (semi-opal), yellow ; from the same place.

a) CH. Cr. Figure unaltered ; its colour turned greyish-white, and it was much disposed to fly in pieces. Some lustre on the outside ; in the fracture, dull and earthy, of a fine grain.—L. of W. 0,06.

b) CL. Cr. The same changes; together with a somewhat brighter lustre.

No. 67. OPAL, *semi-opal of a verdigris-colour (Heliotropium?)*; from Greenland.

a) CH. Cr. Was rendered soft, its fracture of a light-reddish-brown, speckled with a copper-red; glittering, and exhibiting dim-white points and veins.

b) CL. Cr. Rendered not quite so soft by the ignition; and it acquired a liver-colour, with white spots.—L. of W. 0,06.

No. 68. PITCH-STONE, yellow; from *Meißen*.

a) CH. Cr. A greyish-white glass; though clear in itself, yet full of froth-bubbles. The outer surface presented a deep-grey, shining crust.

b) CL. Cr. The same; but without the external incrustation.

No. 69. PITCH-STONE, blue (so styled); from *Menilmontant*, near Paris.

a) CH. Cr. Became soft, yellowish-white, and split or cleft in the manner of slate.

b) CL. Cr. The same changes; except its colour turning light-brown.—L. of W. 0,08.

No. 70. SHISTOSE PORPHYRY; from *Schlossberg* near *Toplitz*. (Its chief mass the *Klingstein*, as it is called).

a) CH.



a) CH. Cr. Run into a dense, very shining glass, of a grey tinge inclining to deep-green; transparent in small fragments, and inlaid with detached, nearly tin-white grains of iron.—L. of W 0,05.

b) CL. Cr. A compact brownish-black glass, with transparent edges, and a conchoidal fracture.

No. 71. PORCELAIN JASPER, yellow; from Bohemia.

a) CH. Cr. Suffered no alteration in its form; but was rendered somewhat contracted, of a deep steel-grey, and dull.

b) CL. Cr. Figure unchanged; externally yellowish-brown; in the fracture, black and glittering.

No. 72. PRASE; from *Breitenbrunn*.

a) CH. Cr. Its form unaltered; externally of a grey-white, shining, inlaid with transfused grains of iron. Its fracture, greenish-white, of a faint lustre, and uneven. Totally opaque.—L. of W. 0,03.

b) CL. Cr. The form likewise unaltered; externally of a smutty-greenish white, glossy, and spotted with minute drops resembling pitch. Fracture grey and dim.

No. 73. QUARZ, red; from *Rabenstein*.

a) CH. Cr. No change in the figure; colour entirely pale reddish-white; slightly transparent; and invested with a delicate glazing.—L. of W. 0,03.

b) CL. Cr. The same.

No. 74. RUBY, rose-red, *oriental*.

a) CH. Cr. No alteration; except its surface having become a little dimmed.—Also without L. of W.

b) CL. Cr. Entirely unchanged. Its colour even seemed to be rendered still purer and more lively than before ignition.

No. 75. MUSCOVY GLASS (*Glist, Mica*); from *Siberia*.

a) CH. Cr. In order to inclose it in the crucible, several lamellas were rolled up. The outer ones became grey, glazed and brittle; the inner ones black, like tinder, and continued flexible.—No. L. of W.

b) CL. Cr. Every one of the lamellas thoroughly hardened by the ignition, glazed, brittle, rendered nearly sonorous. Colour changed to a greyish-white; the surface in part also light-brown.—No. L. of W.

No. 76. SAPPHIRE, azure-blue; from *Ceylon*.

a) CH. Cr. Without alteration; except the surface, which became a little dusky, and dim and muddy.—No loss of weight.

b) CL. Cr. Likewise unaltered. However, the colour was rendered in some pieces paler, and at the same time slightly opalescent.

No. 77. PRISMATIC SHOERL, black, longitudinally streaked; from *Cornwall*.

a) CH. Cr. Little change in the figure. Outwardly, still preserving, in part, the prismatic form, with grains of iron exuded



exuded. Fracture grey, of but little gloss, resembling that of fat.—L. of W. 0,09.

b) CL. Cr. Imperfectly fused; on the upper part brown, with glittering points. Fracture of a blackish-grey, slightly resplendent, with a greasy lustre, and exhibiting fine pores.

No. 78. SHOERL, black crystallized, in columns of nine sides; from St. *Gottbard*.

a) CH. Cr. Externally ash-grey, and very much shrivelled. In the fracture presenting a compact, smoke-grey, moderately shining scoria; with several large bubbles, containing on the inside disseminated granular particles of iron.—L. of W. 0,08.

b) CL. Cr. Fused into a tough, pale, olive-green slag, of a moderate gloss like fat; with several large air-bubbles.

No. 79. SHOERL, black, in large hexagonal columns; from *Greenland*.

a) CH. C. Converted into a scoria of a greenish-grey tinge, and transparent fragments. Its surface was coated with a dusky crust, and scattered grains of iron.—L. of W. 0,07.

b) CL. Cr. An olive-green slag, transparent in thin splinters, of considerable compactness, and a wrinkled surface.

No. 80. SERPENTINE, blackish; from *Zöblitz*.

a) CH.

a) CH. Cr. Indurated; externally covered with a ferruginous crust, together with small grains of iron. In the fracture, splintery, dull and of a grey colour.—L. of W. 6, 12.

b) CL. Cr. Rendered hard. The surface glittering, glazed in part, and passing from iron-black to a copper-red. Towards the edges of the fracture likewise iron-black, but in the middle of a pale greenish-grey; smooth and dull.

No. 81. EMERALD; from *Peru*.

a) CH. Cr. Entered into an imperfect fusion, and preserved its green colour, though somewhat fouled. It also was rendered opaque, and presented detached minute grains of iron.

b) CL. Cr. A clear, greenish-white glass, with a few radiating points,

No. 82. EMERALD? oriental; (perhaps green sapphire?)

a) CH. Cr. Quite unaltered in shape. The colour was rendered somewhat duller, and verging towards grey. The surface partially covered with a rough crust; some pieces reflected changeable variegated colours.

b) CL. Cr. Figure and lustre as before. Turned opaque. The green colour in part passed to a white, and in some pieces the variegated reflection of colours was still more distinct.

No. 83. SPINELL (Ruby).

a) CH.



a) CH. Cr. Suffered no change, excepting that its surface became somewhat muddy and foul.—No loss of weight

b) CL. Cr. Part of it was imperfectly melted to a blackish-brown scoria, into which were cemented the other pieces, whose colour and transparency were unimpaired.

No. 84. ACTYNOLITE (Strahlstein) common, green; from St. Gotthard.

a) CH. Cr. Externally covered with a ferruginous crust, and numerous grains of iron. The inside shewed a grey and dull scoria, full of bubbles.—L. of W. 0,04.

b) CL. Cr. Converted into a fibrous slag, of a greenish-grey fracture, and a brown surface, crystallized in a radiated form.

No. 85. ACTYNOLITE, common, leek-green; from Petersburg. (Swed. Hornblenda).

a) CH. Cr. Like No. 84. a); only with but few grains of iron in the surface, and with acicular crystals in the froth bubbles.—L. of W. 0,04.

b) CL. Cr. A leek-green, and at the top red-brown, compact scoria; of a fine striated fracture, and efflorescent crystallization.

No. 86. ACTYNOLITE, common, in separate parallel prisms; from Carinthia.

a) CH. Cr. A dull, bluish-grey scoria, full of bubbles and its surface inlaid with grains of iron.—L. of W. 0,04.

b) CL.

b) CL. Cr. A dense, greenish-white, and in the fracture indistinctly radiated slag. On the upper surface crystallized in interwoven, reticular, fine, brown needles.

No. 87. GLASSY ACTYNOLITE; needle-shaped, of an intermediate colour between deep mountain-green, and black-green; from *Taberg*.

a) CH. Cr. As No. 86, a). Its crust had in some places a cupreous lustre.—L. of W. 0.12.

b) CL. Cr. Fused into a dense, greyish-white, opaque scoria, marbled of a brown-yellow at its top.

No. 88. GLASSY ACTYNOLITE, acicular, white; from *Taberg*.

a) CH. Cr. A greyish-white mass, fused in a spherical form; on the upper part with separate, recumbent, shining radiations; on the under part mixed with grains of iron. Fracture uneven, dull and rough; in parts striated.—L. of W. 0.20.

b) CL. Cr. A greenish-white, dense scoria, with a glittering greenish-yellow very fine efflorescent surface of small stellular points. Fracture finely fibrous and resplendent.

No. 89. ACTYNOLITE, olive-green, in prismatic crystals; from *Dauphiné*.

a) CH. Cr. The pieces did not fuse together, but were merely conglutinated firmly. External surface, iron-black, with small ferruginous grains, oozed through. Inside steel-grey, fine earthy, and dull.—L. of W. 0.15.

b) CL.



b) CL. Cr. Melted into a highly resplendent glass; of a black-brown colour; flat conchoidal fracture, and transparent splinters.

No. 90. ACTYNOLITE, crystallized in prisms, deep blackish-green; from *Zillerthal* in Tyrol.

a) CH. Cr. Fused into a spherical, moderately splendid, opaque scoria, of a bright greenish-grey colour, and perfectly radiated fracture, surrounded with grains of iron.—L. of W. 0,06.

b) CL. Cr. A strongly resplendent, compact, opaque slag, internally almost apple-green; of a conchoidal fracture, and yellow surface, mixed with brown.

No. 91. STRONTIANITE.

a) CH. Cr. Form unaltered. Hardened by ignition; rendered dull, and very caustic.—L. of W. 0,31.

b) CL. Cr. A clear, bright grass-green glass.

No. 92. TALC (of the *magnesian* or *muriatic* genus); greenish-white; from *St. Gotthard*.

a) CH. Cr. Became hard; split like slate; grey white; in two places slightly united with the crucible by fusion.

b) CL. Cr. Rendered yellowish-white; hardened by the ignition, and acquiring flaty rifts.—L. of W. 0,05.

No. 93. TALC, Venetian.

a) CH. Cr. Indurated, flaty, bluish-grey; in part with a thin red covering.—L. of W. 0,08.

b) CL.

b) CL. Cr. The same change. Its colour brown, resembling decayed mica.

No. 94. TOPAZ; from *Brasil*.

a) CH. Cr. Rendered white, dull, untransparent; of a fine earthy and longitudinally striated fracture.—L. of W. 0,20.

b) CL. Cr. The same; with thin flakes, burst off.

No. 95. TOPAZ; from *Schneckenstein*.

a) CH. Cr. As No. 94, a).—L. of W. 0,20.

b) CL. Cr. As No. 94. b).—L. of W. 0,20.

No. 96. TREMOLITE, radiated; from *St. Gotthard*.

a) CH. Cr. Ran into an opaque, grey-white, round scoria; of a foliated texture, and a radiated crystalline surface.—L. of W. 0,05.

b) CL. Cr. A compact, greenish-white slag, with little lustre, and of a radiated fracture.

No. 97. TRIPOLI; from *Menil-Montant*, (the matrix of what is called *blue pitch-stone*.)

a) CH. Cr. An indurated, very contracted, black-grey, finely porous scoria.

b) CL. Cr. Its outer surface brownish and glittering; its internal surface, or fracture, yellowish-grey, dull, and porous like *sp<sup>u</sup>se*.—L. of W. 0,20.



No. 98. TOURMALINE, green, transparent; from  
*Brazil.*

a) CH. Cr. Hardened by the ignition. The sides compressed inwards. Externally black-brown; internally greenish-grey, opaque and dull.—L. of W. 0,10.

b) CL. Cr. The same change; but of a blacker tinge. The part of the crucible, in contact with it, covered with a brown glaze.

No. 99. TOURMALINE, black; from *Spain.*

a) CH. Cr. Hardened, and the crystals conglutinated. Outside black, with cross rifts and dull; inside dim grey-white. Fracture, conchoidal. Slight gloss of the greasy kind.—L. of W. 0,15.

b) CL. Cr. Externally the same. The fracture, of a steel-grey, but with rather less lustre, and with fine pores.

No. 100. TOURMALINE, black; from *Zillerthal.*

a) CH. Cr. Assumed a very irregular shape. Externally like No. 99, a); inwardly, of a conchoidal fracture, a smoky grey colour, and greasy lustre.

b) CL. Cr. Tough; diffused by melting; light-brown, opaque, and of a middling greasy lustre.

No. 101. UMBER, (brown iron-ochre); from the neighbourhood of *Cologne.*

a) CH. Cr. Gave a dense, opaline glass; of a bluish-grey in the fracture, transparent when in small splinters, and of a strong greasy lustre. It was coated with a grey-white

white crust, finely dotted by very minute froth-bubbles. At the bottom was one considerable grain of iron, which separated of itself.—L. of W. 0,33.

b) CL. Cr. Fused into a solid, black glass; whose upper part was covered with a crust of the specular iron-ore, (*Eisenglanz*) very delicately efflorescent, and radiated in a stellular form.

No. 102. UMBER; from *Cyprus*.

a) CH. Cr. Like No. 101, a) except that its crust was still more minutely dotted, and the inward colour of a clear smoke-grey.—L. of W. 0,33.

b) CL. Cr. Like No. 101. b)

No. 103. VESUVIAN, light-brown.

a) CH. Cr. A dense, clear, strongly resplendent, nearly colourless glass. The outer surface was rather muddy, and was formed into groups of regular crystals (*drusigt*) exhibiting very minute short protuberances, each of which ended in a point, by means of four triangular, exceedingly fine striated facets. Numerous grains of iron were imbedded in its under surface.—L. of W. 0,25.

b. CL. Cr. A compact, very dark olive-green glass; of a bright lustre, and flat conchoidal fracture.

No. 104. VOLCANIC ashes; (from the eruption of Mount Vesuvius, collected at *Naples* in the summer of 1794.)

a) CH. Cr. Melted into a compact glass, of a dirty olive-green; small fragments of which transmitted light. It contained some pieces of iron.—L. of W. 0,10.

i

b) CL.



b) CL. Cr. A dense, brownish-black glass.

No. 105. WACKE (a variety of basalt, commonly ranked among the species of argillaceous earths); from *Joachimsthal*.

a) CH. Cr. As No. 7. b).

*Note.* The same specimen was again put into the charcoal-crucible, after it had been separated from the grains of iron. When taken out, it was tuberous or knobby. The surface presented a glittering black-brown incrustation, whose fracture had a slight lustre. But the interior mass had become pale-grey, and denser than before.

b) CL. Cr. The same change as No. 7. b)

No. 106. FULLER'S EARTH (*Smectis*) genuine; from *Hampshire*.

a) CH. Cr. A compact opaque scoria of a dull grey, with many grains of iron.—L. of W. 0,25.

b) CL. Cr. A dense, blackish-green scoria. Its smooth surface exhibiting red dots.

No. 107. WITHERITE; from *Anglezark*.

a) CH. Cr. In experiments repeatedly made with this substance, the inner charcoal-crucible was found consumed for the greatest part. Hence the witherite always entered into an imperfect fusion with the contiguous part of the clay-crucible, which served as a case to the charcoal-crucible.

b) CL.

b) CL. Cr. A green, somewhat turbid, and frothy glass.

No. 108. ZEOLITE, compact, siliceous, (*Prehnite*); from *Scotland*.

a) CH. Cr. Fused into a compact, deep-grey, opaque scoria. Fracture, imperfectly conchoidal, and highly glittering. Coated with a ferruginous crust; and containing a few minute grains of iron.—L. of W. 0,05.

b) CL. Cr. An opaque dense slag. Its surface olive-green; the inner mass, celadon-green, and the fracture glittering.

No. 109. ZEOLITE, radiated; from *Ferröe*.

a) CH. Cr. Swelled up into an ill-shaped, greyish-white, transparent scoria; full of froth bubbles.—L. of W. 0,16.

b) CL. Cr. The same; but as white as snow.

No. 110. ZEOLITE, volcanic grey; (according to *Fichtel*—according to others, zeolitic pitch-stone) from the Mount *Pap-Laffö*, near *Telkebanya*.

a) CH. Cr. A glass of a dim, black-grey colour; of a clear transparence on the edges; of a greasy gloss in the fracture; and shewing separate bubbles. It also had very small grains of iron in several parts of its external surface.—L. of W. 0,05.

b) CL. Cr. Yielded a dense, bright greyish-white, transparent, but not thoroughly clear glass; rendered turbid by very minute froth-bubbles. Its smooth surface polished



ferred a great splendour, and was marked with dispersed brown-red spots, resembling agates.

No. 111. ZEOLITE, volcanic red; from the *same place*.

a) CH. Cr. Like No. 110. a)

b) CL. Cr. Like No. 110. b); only somewhat more turbid.

No. 112. CIRCON (Jargon); from *Ceylon*.

a) CH. Cr. No change, excepting that its colour turned white-grey, and its surface became a little more turbid.—Also no L. of W.

b) CL. Cr. Likewise unaltered. The greenish colour had almost disappeared, and in its stead succeeded a reddish, bluish, and in part perfectly white one. Several pieces emitted a whitish lustre.—No loss of weight.

Concerning the utility which these experiments on fusion may afford in various respects, I shall make only one or two remarks.

On reviewing the division of stones and earths into *fusible* and *infusible*, which has been hitherto adopted, we observe that several of them are classed among the first; which, however, are not fusible of their own accord, but acquire that property only by the co-operation of extraneous causes. Thus, if we observe the *Strontionite* (No. 91), the *Compound-spar* (No. 16), *Sidero-calcite* (No. 20), *Marble*, (No. 56), and in general all the species of calcareous earth, to vitrify in the melting-vessels, it is owing to the *argillaceous earth* of the clay-crucible, which by its contact effects the fusion of those stony matters, which, when alone, are infusible.

With respect to many other substances, the cause of their vitrification is their ferruginous contents; for *oxyd of iron* likewise promotes the fusion of many compositions, otherwise not vitrifiable. This vitrification, therefore, cannot take place in *charcoal-crucibles*; because in these, the calx of iron loses its vitrescent property, by being reduced to reguline iron, and hence is rendered incapable of continuing in chemical solution or combination with unmetallic-earths. It then separates from them by a kind of eliquation.

An instance of this is afforded by the *Basalt*, (No. 6—10), usually represented as a body, which very easily melts into a black glass. But this fusibility of basalt obtains only when its ferruginous part finds no opportunity to be reduced and to separate: for after this is withdrawn, the remaining portion of basalt is no longer vitrifiable. It now appears, if examined by a lens, as a body almost wholly corroded; and it is not converted into a scoria, unless after continued exposure to the most violent fire.

It is worth remarking, that, in the charcoal-crucible, not only is the iron of such fossils, as contain it in a very slight quantity, as *Pumice-stone* (No. 15), *Boracite* (No. 19), *Mica* (No. 38), completely reduced; but also, that even some species of stones, which in no manner undergo real fusion, nay, which hardly seem to become softer, as the *Ligniform Asbestos* (No. 11), *Chrysolite* (No. 25), *Brown-red Semi-opal* (No. 65), *Prase* (No. 72), and *Serpentine* (No. 80), do nevertheless deposit, as it were by exsudation, most part of their iron.

The proportion of the ferruginous contents thus discovered, may serve at the same time to determine in dubious cases the classification in the mineralogical system. That is to say, it may assist to decide, whether a fossil, whose  
pro-



proportion of metallic parts is as yet unknown, should obtain a place in the class of earths and stones; or, whether it ought to be ranged in the genus of iron-ores.—Such is the case with *Umber*. Of one hundred parts of *umber* from *Cyprus* (No. 102), there remained 67; and the iron, reduced from this residuum, amounted to 37; but the vitreous scoria, only to 30.—Of one hundred parts of *umber* from *Cologne*, there likewise remained 67, of which 35 were iron, and 33 were scoria. This mineral, therefore, as much deserves a place under the genus of iron-ores, as several other iron-ores, less rich in ferruginous contents. It may be considered, either as a particular species of the brown iron-stone; or as a variety of brown iron-ochre.

Besides, the trials made with fire may be of some utility with regard to those fossils, concerning which the opinions of the learned are yet divided, with regard to the means employed by nature for their formation. I even think, that in this branch of *geological* researches, the experiments made by *means of fire*, are rather more decisive than the analysis in the *moist-way*. Although it is quite contrary to my intention to enter into this dispute, yet I think myself obliged to state my own private opinion respecting this subject, independent of the authority of others; which is, that I cannot rank among the products of fire, either the genuine *basalt*, or its kindred *wacke*, or the *porphyric-slate*. In this persuasion I am confirmed by personal inspection of basaltic districts, especially of the *Bohemian middle mountains*; as well as by the habitudes of the above minerals in fire. No. 6—10; 105; 70.

On the contrary, as to what relates to the generation of the *Obsidian* (No. 58, 60), *Pumice-stone* (No. 15), and pretended *Volcanic Zeolite* (No. 111, which last is reckoned by some among the *Pitch-stones*), &c, I willingly renounce

my own opinion; adding only, that, on considering the arguments for and against their volcanic origin, the circumstance of the obsidian and pumice-stone giving in fire exactly the same products, should not be disregarded; and also, that both these fossils, not only accompany each other at *Lipari*, but likewise frequently occur actually blended.

As the chemical analysis in the humid way is embarrassed with many difficulties, that check the progress of our knowledge of the constituent parts of fossils; the speedier examination, by means of fire, of a fossil, not yet analysed, may serve as a previous hint for assigning to it its proper place in the systematical arrangement. It may also tend to correct the classification of several minerals whose characters are not sufficiently distinct, or perhaps have led to error. So, for instance, the above results plainly shew, that the *Cats-eye* is not a fel-spar (No. 48, 49); that the *Leucite* does not belong to the garnets, and as little to the fel-spar (No. 55); that the *Telkebanya-stone*, or *brown-red Semi-opal*, is not allied to the vitrifiable pitch-stones, among which it has been ranged on account of its perfect opacity (No. 65); and that the *Granatite* cannot be classed under the garnets (No. 41); nor the *Cyanite* under the striated schists (No. 28); nor the *Chlorite*, under the varieties of mica (No. 23.)

However, the inferences drawn from these experiments, should not be carried too far; nor should a decisive conclusion be made on the constituent parts of a fossil, merely from its changes in the fire. For, in this respect, the *analysis in the humid way* is absolutely the only safe guide.

## II. ANALYSIS



## II.

## ANALYSIS

## OF THE

*BLACK-GREY FLINT.*

(Common Flint; *Feuerstein* of the Germans.)

IN order to reduce to the requisite most subtle pulverulent state the harder kinds of stones, which are to be subjected to a chemical analysis, I make use of a grinding concave shallow vessel or bowl, wrought, as well as its appropriated mullar, of black-grey flint. The body, which is to be finely ground in it, being previously pulverized in a polished steel-mortar, gently ignited and accurately weighed, I moisten with water, and continue the trituration, until the stone is reduced to an impalpable powder. A shorter or longer time is necessary for this operation, according to the degree of hardness; so that 100 grains of the more indurated species of gems often require trituration for three or four hours. After the finely powdered mass is again desiccated in the air, or in a gentle warmth, I ignite the powder, carefully collected from the trituration-dish, in a silver or porcelain-crucible, with a low heat, and weigh it once more.

Stones, the hardness of which does not surpass that of flint, weigh then no more than at first. But such as are harder than flint, acquire an increase of weight; which in some gems, as the sapphire, adamantine-spar, and chrysoberyl, often amounts to from 10 to 13 *per cent.*

Therefore, as this addition of weight must, of course, be again subtracted from the sum of the constituent parts of the decomposed body, an exact chemical knowledge of the substance, of which the grinding vessel consists, is indispensable. And, no doubt, common flint would be little eligible for the grinding of hard stones, if, besides the filex, its chief ingredient, it contained other earths in that quantity, which is stated by mineralogists; and of which aluminous earth is said to make up from 18 to 20 parts in the hundred.

But from an exact and repeated analysis of this flint, I am convinced that the quantity of foreign earths, which are here combined with the filex, is far less considerable, and that in general the sum of them only amounts to *one grain*. On this account, and considering the small number of grains abraded from the flint mortar, it would appear a superfluous nicety, to bring into calculation the small fractional parts of the other earths, besides the siliceous.

a) *Five hundred* grains of common flint, coarsely bruised, were ignited for half an hour in a covered crucible. They lost, by this, five grains of weight, and turned greyish-white.

b) *A Hundred* grains of flint, reduced to the finest powder, were mingled with three times their weight of caustic-pot-ash, and exposed to a red-heat in a silver-crucible for  
half



half an hour; by which management, however, the mixture did not fuse, but continued a loose, friable mass. When covered with water, it was all dissolved, without any residue, and afforded a somewhat turbid liquor.

c) By over-saturating this solution with muriatic acid, the *siliceous earth* was precipitated; which, after a due digestion, was separated, washed, and ignited.—It weighed 97 grains.

d) The acid fluid, thus separated, when saturated with carbonat of soda, let fall a brownish earth; which re-dissolved in muriatic acid, and left siliceous earth, weighing one grain after ignition.

e) The remaining muriatic solution afforded, with caustic ammoniac, a brown, mucilaginous precipitate; which, when added, while yet moist, to caustic lye, deposited *oxyd of iron*, weighing after ignition one quarter of a grain.

f) When this portion of iron had been separated, I mixed the caustic lye with muriatic acid to excess. Being then saturated with mild salt of tartar, it was put in a warm place. A small portion of earth fell down; which, after gently drying, weighed one half grain, and its solution in sulphuric acid afforded aluminous crystals. This aluminous earth would have weighed one quarter of a grain in its dry state.

g) The edulcorating waters, after being collected, evaporated to dryness, and the residual saline mass, again dissolved in fresh water, deposited three quarters of a grain more of an earth, which dissolved in muriatic acid, with effervescence, and yielded selenite or gypsum, on dropping sulphuric acid into it. It was consequently *calcareous earth*,  
which,

which, if free from carbonic acid, would have amounted to half of a grain.

Hence the constituent parts of common flint amount in one hundred to

|                        |         |      |       |      |         |
|------------------------|---------|------|-------|------|---------|
| Ignited <i>flex</i>    | -       | -    | c)    | . 97 | } . 98, |
|                        |         |      | d)    | . 1  |         |
| — — —                  | Lime    | . g) | . . . | 0,50 |         |
| — — —                  | Alumine | . f) | . . . | 0,25 |         |
| Ignited oxyd of iron   | . . .   | e)   | . . . | 0,25 |         |
| Parts volatile in fire | . . .   | a)   | . . . | 1,   |         |
|                        |         |      |       |      | <hr/>   |
|                        |         |      |       |      | 100     |



## III.

## CHEMICAL EXPERIMENTS

ON THE

## ADAMANTINE SPAR.

## FIRST SECTION\*.

NATURE, inexhaustible in its riches, has intended, as it were, to keep in activity the ardour of Naturalists, in the discovery, examination, and arrangement of the fossil products, by presenting new species that have remained hitherto unknown, and whose proper place has been too frequently mistaken in artificial classifications. This truth has been confirmed, in an eminent degree, by the *adamantine spar*.

The native places of this stone are *China* and *Bengal*; and from each of these countries it was first brought to Europe, for the celebrated cabinet of *Charles Francis Greville*, Esq. in London. The denomination of *adamantine spar*, given to it by English Naturalists, is grounded not only on its uncommon hardness, similar to that of diamond;

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\* Read in the Royal Acad. of Sciences at Berlin. See *Recherches chimiques sur le Spath adamantin*; in the *Memoires de l'Acad. royale etc*, Août 1786, jusqu'à la fin de 1787. Berlin 1792.

but also on its application ; for the Chinese and Indian lapidaries make use of the powder of this stone instead of the real diamond-powder for grinding.

The first public notice taken of the adamantine spar which I know of, is contained in the second Volume of *Sage's Analyse chimique et concordance des trois regnes* ; where this writer states the above fossil to be a granite, composed of fel-spar, black-shörl, and quartz. A more accurate account of it, together with a description of its external appearance, was afterwards given by *de la Metherie* and *Abbé Hauy* in *Rozier's Journal de Physique*, for January and March 1787.

But as no Chemist has ventured to undertake its chemical analysis, *Mr. Greville* was so obliging as to sacrifice a quantity of this substance, in his possession, sufficient for its examination, and to send it me for that purpose.

The adamantine spar presents two distinct varieties, according to the two different countries which give it birth. The first, which is found in China, when regular, assumes a columnar form of six sides, without terminating points. The size of the specimens which I have seen, was from an half to a full inch in height, and three quarters of an inch in thickness.

The colour of this stone is grey, of various shades, partly verging to the brown of hair. The entire pieces are opaque ; but in thin lamellas, and on the edges transparent. Its fracture is glossy, and exhibits a fine spatose or foliated texture ; on account of which, even its outer surface appears finely striated. Its lateral facets are mostly coated with a delicate, firmly adhering crust of micaceous scales of a silvery lustre, and in some places intermingled with particles



cles of red fel-spar.—One specimen was also covered with a delicate yellow *fulphur pyrites*.

This stone is exceedingly hard. For this reason, it not only cuts glass with as great facility as diamond, but it also scratches rock-crystal and other hard stones, and is employed, as already mentioned, for cutting and polishing even gems.

Its specific gravity I found to be 3,710.

An accidental characteristic mark of this Chinese adamantine spar is, that it contains magnetic iron, disseminated in small crystalline grains, which are easily separable by means of the load-stone, if the stone has previously been bruised to a moderately fine powder.

The second variety, or Indian adamantine-spar, from Bengal, called by the natives *Corundum*, is distinguished from the Chinese by a whiter colour, by a more decidedly sparry texture; and by the magnetic iron, which it likewise contains, consisting of still smaller grains, but not interspersed within its substance, but merely adhering to its surface.

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With the *Chinese Adamantine Spar* I made the following Chemical Experiments.

By strong ignition for an hour it lost  $1\frac{1}{2}$  per cent. of weight; but suffered no alteration, except having become a little whiter. Before the blow-pipe upon charcoal, it was  
not

not in the least attacked, either by soda, or by borat of soda; or by the compound of phosphat of soda and ammoniac (*phosphoric salt of urine.*)

In order to guard against accidental impurities, I bruised the stone on the anvil, between many sheets of strong paper. I then picked out the purest pieces; heated them to redness, and quenched them in water. However, this operation being several times repeated, was found useless; and the hardness of the stone was not at all thereby diminished. It was next triturated in an agate mortar to the finest powder; and upon 300 grains, or five drachms of this powder, introduced into a retort, twice its weight of aqua regia was poured. By strong digestion, I obtained from it a golden-yellow tincture of iron. This digestion was once more repeated with a fresh quantity of the same acid. I then precipitated the dissolved iron by caustic ammoniac; which precipitate, after edulcoration and ignition, was all attracted by the load-stone.

My next step was to examine whether the decanted fluid contained calcareous earth.—For this purpose I combined it with mild ammoniac; but no trace of this earth appeared. Therefore the acid had only extracted that portion of iron, which is simply disseminated in the adamantine spar; but does not belong to its composition.

The powder remaining after the extraction of the iron was of a bright ash-grey. This I mixed with double its weight of salt of tartar\*, and ignited it in a silver-crucible, during two hours in a brisk fire. But on softening again this mass by distilled water, I soon perceived, that no *resolution*,

\* Pot-ash, or vegetable alkali, prepared from tartar.



or separation of parts, had taken place in the intrinsic mixture, or composition of the stone: nor did the alkaline solution let fall any precipitate, when saturated with acids.

Convinced by other experiments, that the caustic fixed alkalis have a stronger *resolvent* power, than the mild over stones of a firmer texture, I resolved to repeat the operation with the caustic alkali. With this view I prepared caustic soda, with all the precaution necessary for obtaining it in a perfectly pure state.

Equal parts of this caustic salt, and of the powder of adamantine spar, were subjected to ignition in a silver-crucible for the space of two hours. After this, the calcined mass, which had become very compact and hard, was triturated with distilled water; super-saturated with muriatic acid, and digested. The acid extracted merely a pale yellow tincture, which still contained a slight ferruginous impregnation; but nothing of an earthy nature. When the residual powder was again washed, and ignited, it was of a light grey-white colour, and weighed 240 grains. So that 60 grains, making the fifth part of the first weight of the crude stone, must be taken for the iron disseminated in, and now separated from it by acids.

These 240 grains I mixed with four times their weight of caustic mineral alkali; and ignited them in a crucible made of silver, as long as the vessel would bear it, without itself fusing. After refrigeration, the mass was so firm and so hard, that in order to bring it on the filter, I was under the necessity of softening it by long tedious boiling in distilled water. The alkaline solution, saturated with muriatic acid, now dropped a white, very loose earth; which, from previous conjecture, I then imagined to be siliceous. But this was not the case, for it was rapidly and clearly re-

dis-

dissolved by a slight excess of acid, and proved to be rather aluminous on farther trial. And by accurately saturating the solution with salt of tartar, I reproduced it again in the form of a precipitate, and collected it.

The powder, left on the filtering-paper, had an isabella-yellow colour, and had become looser. I poured upon it four parts of aqua regia; but it soon formed with it a thick gelatinous coagulum. Having added four parts more, I digested the mixture in a boiling heat. Which being done, it was diluted with hot water, and, after filtration, saturated with salt of tartar. By this management a white loose earth precipitated, and was aluminous, like the preceding.

I next repeated the same operation with the 140 grains of the powder of this stone that remained in the last-mentioned process: that is to say, I added four parts of caustic soda, and heated it to redness for five hours in a silver-crucible. As in the preceding experiment, so in this, the mass became exceedingly hardened, and of difficult solution, even in boiling water. Its filtered lye likewise deposited, on the addition of muriatic acid, a white loose earth; which, in the same manner, entirely dissolved without any turbidness, by an excess of the acid. Having been again precipitated by mild alkali, I collected and added it to that which was obtained in the last process.

In the same manner, as mentioned above, I treated the residue that remained behind on the filter after the separation of the alkaline lixivium, by digesting it in aqua regia; and the small portion of earth, extracted from it, was likewise precipitated by salt of tartar.

The undecomposed part of the powder, which at this period weighed 103 grains, I subjected a second time to calcination,



nation, during five hours, being previously mixed with a quadruple proportion of caustic alkali. The result agreed with that of the foregoing process. From the filtered alkaline solution of the mass, softened with difficulty, acids threw down a slight quantity of loose earth; which was re-dissolved when the acid was added to excess. Having been again precipitated by the addition of alkali, it was then collected.

I next put theedulcorated residue, weighing now but 92 grains, in digestion with six parts of nitric acid. The powder of the undecomposed adamantine spar continued, as before, lying at the bottom, like an heavy fine sand. But when the mixture had begun to boil, I perceived an unexpected alteration. The powder swelled; rose from the bottom of the matrafs towards the surface of the liquid, and changed its sandy appearance to that of a flocculent precipitate, nearly of the same form, with recently precipitated muriat of silver; but, on continuing the digestion, it again fell down in the form of an incoherent powder. This last acid likewise extracted a small portion of alumine; which I collected, after precipitating it by pot-ash.

The remaining powder of the adamantine spar, whose weight after ignition amounted to 74 grains, was treated in precisely the same manner as before, only with this difference, that I increased the proportion of caustic alkali, of which I now took a sextuple weight. After the mass had been ignited for five hours, and refrigerated, it was found, as in every previous operation, to be very difficultly soluble in boiling water. At this time, by the addition of an acid to the filtered solution, a less quantity of loose earth, than before, was precipitated; but which even now was not siliceous earth. Boiling nitric acid likewise extracted from the residual powder a little aluminous earth.

When the adamantine powder, remaining after these repeated strong calcinations with alkali, was put on the balance, its weight was found to be 60 grains. It appeared now in the form of a fine, filiceous earth; and in order to examine it as such, I mingled it with one ounce of mild soda; upon which it was strongly calcined in a small silver-crucible, and at length urged to fusion. The crucible was left uncovered; because I intended to watch attentively, whether the blended mass would effervesce, during the action of the carbonated alkali, and thus betray a filiceous nature. The fusion, however, went on without the least frothing; and by this I was sufficiently convinced, that the earth under trial was not yet purely filiceous.

The melted mass proved, after refrigeration, to be as difficult of solution in water, as before. This alkaline lye, passed through the filter, shewed no appearance of having taken up any foreign substance. It remained perfectly clear and limpid, when saturated with acids; some few, hardly perceptible flocks, excepted.

I now endeavoured to separate something from the residue, againedulcorated, by means of strong sulphuric acid. Eight times its weight of this acid was accordingly poured upon it, and again with proper precaution distilled off from it to dryness. The residue, softened by hot water, was put on the filter, and the acid liquor, which passed through the paper, was saturated with pure vegetable alkali. Yet, even with this treatment, I only obtained a very slight indication of alumine.

On considering this great obstinacy of the remainder left from the adamantine spar, which by the last operation hardly lost one grain of weight, I again recurred to the caustic mineral alkali. The powder, mixed with a tenfold quantity



tity of soda, was first ignited for four hours; increasing afterwards the intensity of heat, until the mass entered into a thin fusion, in which state it was kept two hours. The silver-crucible would not longer resist the action of the fire; it was injured, though without detriment or loss of the mass, which was again with difficulty liquified in water, and then filtered.

The alkaline lixivium, thus obtained, deposited a tender earth, upon saturation with acids. But even this earth was not yet siliceous. It disappeared by a slight excess of the acid; and separated again, as soon as the point of saturation was restored, by the addition of alkali. When thus recovered, it was freed from adhering saline particles by washing, and added to the precipitates, obtained in the preceding operations.

Upon the remaining portion of adamantine spar in a pulverulent state, which in this process again had assumed an isabella-colour, I then affused four parts of nitric acid. The mixture thickened to a jelly; on which account I added four parts more of nitric acid, and digested it in a boiling heat. The solution being diluted with water, and filtered, was saturated with salt of tartar; and the precipitate which it afforded, added to the preceding ones.

At this period, the quantity of adamantine spar, which had hitherto resisted decomposition, weighed 34 grains; which were mixed with 15 times their weight of caustic soda, and ignited in a brisk fire, during five hours. Yet, notwithstanding this, the alkaline lye, procured from the re-dissolved mass, and saturated, deposited only a trifling quantity of a flocculent earth; and for this reason no diminution of weight was observable in the residue.

Digested with eight parts of nitric acid, the mixture again acquired a gelatinous consistence: and the acid, separated by filtering, likewise afforded only a scanty precipitate, on being saturated with alkali.

The powder, still undecomposed, weighed now 27 grains; which I blended again with 15 parts of caustic soda, and treated in the manner oftentimes stated. But I observed that the alkali, as well as the subsequent digestion in acids, extracted from it still less than before; since the remaining undecomposed part amounted yet to 24 grains.

I then resolved to try, whether perhaps a stronger degree of heat, than the silver-vessel was capable of bearing, might not give additional force to the action of the alkaline salt, and thus effect the farther decomposition of this stubborn residue. I therefore substituted an iron-crucible to that of silver. This residue, being mixed with four parts of mild pot-ash, and introduced into the iron-crucible, was exposed to a heat sufficiently intense to cause it to melt, and it was then kept for two hours in red fusion. This obstinate body, however, could not be mastered. The liquor, separated from the dissolved mass, held no atom of earth in solution; but remained clear, when saturated with acids.

After the residue, left on the filtering paper, had been freed by means of the muriatic acid from the particles of iron which it had acquired from the melting-vessel, and after it had beenedulcorated and dried, I found it possessed of the same nature as before; and only one grain of its weight was wanting, which I suppose was not dissolved, but lost.

Having thus *eleven times* calcined and fused this stone, with alkali in various proportions, I at last gave up all hopes of conquering this residue, which at each operation  
proved



proved more and more refractory. And not expecting success, even from repeating these tedious processes, that exhausted all patience, I turned my attention to the examination of the several precipitates that had been collected.—But I found that those which were obtained, by means of acids, from the solutions of the masses calcined with alkali, were of nearly the same nature as the precipitates, thrown down by alkalis from the acids, in which the adamantine spar was digested or extracted after every calcination. For this reason I mixed them all together, and chose the sulphuric acid, as the proper test for their examination. This menstruum, consisting of one part of the concentrated acid, diluted with four parts of water, immediately dissolved a considerable part of the earthy precipitate; but another portion remained undissolved, though the acid had been added to excess, and was assisted by a boiling heat. Upon this undissolved earth, when separated by filtration, edulcorated, dried, and introduced into a retort, I poured four times its weight of concentrated sulphuric acid; and having again abstracted this last, by distillation, to dryness, in a sand-bath, I softened the residuum with boiling water, placed it on the filter, and edulcorated the earth remaining on the paper. I found, however, that by this treatment, nothing of importance could be extracted from this earth; for the solution, saturated with alkali, yielded only one half grain of precipitated aluminous earth, which I re-dissolved in some drops of sulphuric acid, and added to the preceding solution.

A small proportionate quantity of pure vegetable alkali being added to this solution, it was made to crystallize by repeated gentle evaporations; after which it shot into regular crystals of alum, which were collected.

I observed, however, that on every crystallization of this solution of alum, a white slimy earth was separated.

I therefore collected it carefully, and treated it in the same manner as the earth mentioned before: that is—I distilled from it four times its weight of strong sulphuric acid; softened the residuum in the retort with water; filtered the liquid which had distilled over, and saturated it with alkali. But hardly one half grain of earth fell down, and this was still aluminous. The earth which remained undissolved, exactly resembled that which has been mentioned before, and was accordingly added to it.

Thus I at length so far succeeded, as to decompose the adamantine spar into two different species of earth. But though the first evidently shewed itself to be aluminous, the nature of the second was doubtful. On superficial consideration, this last might well be taken for siliceous earth; but its habitudes contradicted this supposition.

Encouraged by the hope of coming nearer to the discovery of its true nature, I repeated the operation so frequently noticed, of heating it to intense redness for some time, with six parts of caustic soda in the silver-crucible, and increasing at last the strength of the fire so as to affect its thorough fusion. The melted mass had then acquired a striated crystalline texture. Yet the alkali took up but a small portion of it, as I found by the weight of the undissolved earth, recovered from the calcined mass, after liquefying it by water. The residue, washed and dried afresh, was boiled for an hour with ten times its weight of strong nitric acid; from which, when separated again, and saturated with alkali, only an inconsiderable trace of alumine fell down.

I then saturated with nitric acid the alkaline solution obtained from the melted mass. It let fall a slight quantity of  
fine



a fine earth; not a particle of which was dissolved by nitric acid boiled upon it for some time.

This portion of earth, which was precipitated, and recovered by filtration, ought at last, agreeably to theory, to have assumed the character of pure siliceous earth. To make trial of it, I exposed it with soda to the action of the blow-pipe, in a quantity not exceeding three grains. But it did not prove to be siliceous; on the contrary, I found it to be of the same nature with the whole of the remaining earth, from which it was separated by the mineral alkali during the fusion.

However, in order to make a comparative experiment with real siliceous earth, I mingled a drachm of this last, precipitated from liquor of flints, with four drachms of caustic soda, and exposed them together, in a silver-crucible, to only a moderate ignition. Although this mass was hardly agglutinated by the operation; yet it easily afforded a clear solution in distilled water. And when this was saturated with an acid, the siliceous earth fell down, in its usual manner, in the form of a jelly-like substance, highly intumescend.

From all these processes it is sufficiently obvious, that the adamantine earth in no manner acts like the siliceous. If it were so, it should dissolve in fixed alkalis, by means of a red heat; more especially when caustic alkalis are employed, as was here the case: and it likewise should be recoverable from them by affusion of acids. But the earth, which after the first fusions, was thrown down by acids from the alkaline solutions, was not siliceous, but aluminous, which was immediately and entirely re-dissolved by adding more of acid. And in proportion as the alumine was separated from the mixture of the adamantine spar, by

alkalis as well as by acids, the unknown earth in question more and more resisted each solvent medium.

If filiceous earth, blended with equal parts, or with only one half of its weight of fixed alkali, be exposed to a melting heat, it unites with strong effervescence to the alkali, and affords a clear glass. And this result ensues both in the crucible, and before the blow-pipe, in small experiments. But this is not the case with the other earth. When brought before the blow-pipe in a small silver spoon, a little effervescence seems indeed to take place at the beginning of the fusion; but neither is the effervescence so strong, nor is there a clear vitreous globule formed, as in the first instance. Only a scoriaceous mass, of difficult fusion, remains.

A frit, composed of twenty grains of this earth, with as much carbonated soda, was exposed in a luted clay-crucible, to the strongest heat of the porcelain-furnace, which is so intense, that carrara-marble, or any other calcareous earth, if inclosed in a clay-crucible, melts without any addition, into a very hard, clear, and green glass. The result of this experiment was, an opalescent, very hard, greenish-white glass; the fracture of which, however, exhibited signs of a texture, in divergent lines, radiated from a common centre at the bottom of the melted mass. Whereas filiceous earth, precipitated from the liquor of flints, when mingled with equal parts of soda, as was to be expected, yielded a clear glass in the same degree of heat.

What am I then to think of this earth? Shall I, perhaps, take it for a mixture as yet not totally decomposed, of two or more simple earths, perhaps the aluminous and filiceous?—This opinion is *not without probable ground*. The extreme obstinacy with which the adamantine-spar resists all attempts to decompose it, shews us the high degree



gree of attractive power, by which nature has most intimately mixed and united the constituent parts of this stone. Hence, in proportion as the aluminous earth was forced out and separated from the mixture of this stone, seemed the last residue, which, for a moment, I will suppose to be siliceous, to be more strongly attracted, and secured against farther solution, by its other remaining constituent parts, in the same manner, perhaps, as silver is defended by gold from the attack of nitric acid, when the first is united with the latter by fusion, in a proportion smaller than two to one.

But this *analogy* subsists only in appearance; and it might be applied only in the decomposition of the adamantine spar, by means of acids. For, in that case, the siliceous earth, because itself insoluble in acids, might protect the alumine which is most intimately combined with it; in the same way as gold, by its insolubility in nitric acid, preserves the silver against the action of the same acid, which in general so readily dissolves it. On the contrary, this example does not seem very applicable to the decomposition of this stone, in the dry way, by means of alkali; since, in this case, both earths, the alumine as well as the flint, are soluble in fixed alkalis.

Besides, the above conjecture is opposed by another circumstance. We are taught, by experience, that mixed bodies, whose constituent parts are strongly attracted by each other, may certainly, for a long time, resist the force of solvents; but we also know, by experience, that, whenever the solution has actually taken place, especially when in the humid way, the reciprocal attractive power of the constituent parts is then either totally destroyed, or, at least, so far diminished, that nothing impedes their separation.

This

This is the case with the earth of the adamantine spar: for it has actually been dissolved, conjunctively with the aluminous earth, partly in acids, partly in the alkaline lyes. And it has also been recovered, in the form of a precipitate, from both kinds of solvents.

What inference, therefore, remains?—This earthy substance would not give any further indications of a mixture; and yet it presented none of the specific characteristic marks by which the other simple earths, at present known, are distinguished. Are we not, then, authorized to regard this body as a *new, distinct, simple earth*?—However, I do not venture, at this time, positively to decide on this point. Before this can be done, *repeated experiments must throw more light on the nature of this earth*. Yet, considering the scarcity of adamantine spar, and its discouraging resistance to chemical analysis, there is little hope for a speedy success.

It now remains, to state the *proportion* of the parts found in the adamantine spar.—The grains of *magnetic iron* disseminated through it, constituted the fifth part of its whole weight; for when they had been separated, there remained 240 grains of the 300 employed. But this iron cannot be brought into the computation as a constituent part of the stone.—Its proper constituent parts are, *aluminous earth*, and the above yet *undetermined earth*. After all the aluminous earth, collected in this analysis, had been dissolved in sulphuric acid, and properly crystallized, I obtained from it 2 ounces 6 drachms of alum, in regular crystals. As, therefore, the alumine contained in one ounce of this neutral salt, amounts, when ignited, to 56 grains, it is manifest, that those 2 ounces 6 drachms of crystallized alum contain 154 grains of aluminous earth, free from water.

The



The other yet undetermined earth weighed, after ignition, 53 grains. To these must be added the residue of 24 grains, which remained at last, on the decomposition of the stone, and was insoluble, and perfectly like the other portion. Hence this earth amounts, in the whole, to 77 grains; which, with the 154 grains of aluminous earth, give the sum of 231 grains.

## SECOND SECTION.

THE circumstantial description of my first analytical attempt respecting the adamantine spar (communicated in the foregoing section), may serve as an example to shew the difficulties chemists have but too often to contend with, when examining unknown natural bodies. If the method of decomposing hard stones, pursued in my former enquiry, be compared with the process which will be explained in the present section, it will also appear from thence, how seemingly unimportant the causes often are which at one time ensure success to the undertaking, at another time render it difficult.

By the results of the above experiments, I was induced to enquire, whether that earthy body, which was obtained besides the aluminous earth, did not deserve to be considered as a new, peculiar earth. However, I accompanied this conjecture with the express declaration, that I did not then mean to assert any thing certain; but, on the contrary, that farther experiments could alone decide that question. Nevertheless, I find this substance mentioned by several authors as an earth, the existence of which has been already proved, and named by them *Earth of Adamantine Spar*, *Corundum-earth*, &c.

On this account, I thought myself the more bound to make new researches on the adamantine spar, and to give, if possible, a *complete decomposition* of it, instead of the former preliminary and unfinished examination. Two reasons impose upon me this task; either to throw full light upon its nature if it should, on farther examination, prove to be really a distinct and new earth; or, if the contrary be the case, to prevent in time the spread of an error, occasioned against my intention.

The want of a sufficient additional quantity of this fossil, which still continues to be scarce in Europe, has, however, retarded the execution of this purpose for a considerable time; but other experiments, conducted during that period, have made me acquainted with a shorter and more certain method of analysing gems, and other similar fossil bodies, of difficult decomposition.

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A.

*Decomposition of the Chinese Adamantine Spar.*

a) *Hundred and fifty* grains of hair-brown adamantine spar, from *China*, containing interspersed particles of magnetic iron, were powdered by gentle blows in a mortar of polished steel, and the grains of iron extracted with the load-stone. The separated iron weighed 18 grains.

b) *Hundred* grains of the powder from this stone were then weighed, and most finely levigated, moistening them with water, in a triturating-dish, made of flint. After desiccation the powder appeared of a grey colour, resembling that of wood-ashes, which passed into a brown-red, after gentle ignition. It now weighed  $110\frac{1}{2}$  grains, and consequently had received an increase of  $10\frac{1}{2}$  grains of siliceous earth from the grinding-vessel.

c) *After*



c) After this it was mixed in the silver-crucible with 4 ounces of caustic lixivium, prepared from the purest vegetable alkali, the saline contents of which lye amounted to one half of its weight; and after this the fluid was again evaporated, till the mass was dry. This done, the crucible was removed into the wind-furnace; applying at first a moderate heat, and increasing it gradually, until the crucible was red-hot; in which state it was kept for 3 hours.

d) Upon the refrigerated mass, which had acquired a brown colour and considerable hardness, I repeatedly poured hot water, to soften it by degrees. The several washings being collected in one glass, there fell down a loose earth of a deep ochre-yellow tinge, which, when separated by filtration from the clear liquid, and dried in a gentle heat, weighed 58 grains.

e) Muriatic acid threw down from this alkaline solution a copious precipitate, which was again wholly dissolved by a slight super-saturation with the acid. When decomposed by a boiling solution of carbonat of pot-ash, it produced a white loose earth, the quantity of which amounted, after gentle deficcation, to 201 grains.

f) The above 58 grains of yellow earth (d) were covered with muriatic acid, and committed to digestion. It dissolved in it to a yellow liquid, somewhat turbid, which soon after formed a gelatinous coagulum. After being diluted with more water, and digested, stirring it now and then, it deposited *siliceous earth*, which, when ignited, gave  $4\frac{1}{2}$  grains in weight.

g) I then added mild vegetable alkali to the clear yellowish solution, separated from the siliceous earth by filtering. The brownish precipitate, which I thus obtained,  
was

was sufficientlyedulcorated, and, while yet moist, boiled with caustic lye. There remained a brown residuum, consisting of  $15\frac{1}{2}$  grains, after a gentle drying.

*b*) These  $15\frac{1}{2}$  grains dissolved in the cold, in the muriatic acid poured upon them, and afforded a saffron-yellow solution, but which speedily congealed to a jelly. From this last, diluted in heat with water, there separated *siliceous earth*, whose weight, after ignition, was 3 grains.

*i*) From the muriatic solution (*b*) I now precipitated, by caustic ammoniac, the iron which it contained. It fell down in brown-red flocks, and weighed  $7\frac{1}{2}$  grains, after being exposed to a red-heat.

*k*) From the alkaline solution (*g*), saturated to excess with muriatic acid, the addition of mild vegetable alkali precipitated, in a boiling heat, a white loose earth, which, being gently dried, weighed  $29\frac{1}{2}$  grains.

*l*) Upon these  $29\frac{1}{2}$  grains of earth (*k*), added to the above 201 (*e*), dilute sulphuric acid was affused. When gently warmed, the earth was entirely dissolved; but when the solution had been concentrated by evaporation, it coagulated into an uniform clear jelly. This was again copiously diluted with water, in a warm temperature, and with repeated stirring; upon which *siliceous earth* separated, amounting, when dried and exposed to a red-heat, to 9 grains.

*m*) The clear solution by sulphuric acid (*l*) was now combined with the requisite quantity of vegetable alkali, and by slow evaporation made to crystallize. It constantly yielded, until the end, regular crystals of alum. The last



last remaining liquor, which consisted only of a few drops, I dried to a slimy consistence, which, upon dilution with water, still deposited  $\frac{1}{2}$  grain of *siliceous earth*.

n) After all the crystals of alum, collected from the several liquors, had been re-dissolved in boiling water, I precipitated their earth by carbonat of pot-ash, washed, and dried it. But as the aluminous earth is much disposed, even after the most diligent edulcoration, firmly to retain a portion of the salts, that before were combined with it, more especially the vegetable alkali, whereby its own weight is necessarily increased; I took care to restore it in its true purity, by affusing upon it twelve times its weight of distilled vinegar, digesting it for several hours with this fluid; then adding as much caustic ammoniac as would saturate the acetic acid to excess; and lastly, by a perfect edulcoration of the precipitated *alumine*. When it was afterwards desiccated and ignited, its weight was found to be 84 grains.

o) At last, the *siliceous earth* was put to trial. For this purpose I heated it to redness with four times its weight of mild vegetable alkali, and poured water on the mass which was obtained. It was completely dissolved, leaving only a slight portion of a slimy residue; and deposited again, during saturation with muriatic acid, the siliceous earth in its usual form.

Thus the decomposition of the adamantine spar was fully effected; and every uncertainty respecting the true nature of its constituent parts, that had remained after its first examination, is totally removed.

Hence, when we reflect that the magnetic iron, disseminated in the Chinese adamantine spar, is merely to be

considered as a foreign substance mingled with it, and therefore cannot be considered as a constituent part, the following will be the *constituent parts of adamantine spar*, together with their proportions in the *hundred*.

|                                |                          |      |
|--------------------------------|--------------------------|------|
| <i>Alumine</i> . . . . .       | <i>n)</i> . . . . .      | 84,  |
| <i>Oxyd. of iron</i> . . . . . | <i>l)</i> . . . . .      | 7,50 |
| <i>Silex</i> . . . . .         | <i>f)</i> $4\frac{1}{2}$ |      |
|                                | <i>b)</i> 3              |      |
|                                | <i>l)</i> 9              |      |
|                                | <i>m)</i> $\frac{1}{2}$  |      |

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 17

 From which subtract *b)*  $10\frac{1}{2}$ 


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 There remain . . .  $6\frac{1}{2}$  . . . . . 6,50

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 98

Loss . . . 2

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 100

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 B.

*Decomposition of the Adamantine Spar from Bengal.*

THE *Bengal Adamantine Spar*, or *Corundum Stone*, differs from the Chinese; *first*, in containing no interspersed magnetic iron, of which only now and then some few grains adhere to its external surface; and, *secondly*, in this, that the ferruginous part, belonging to its chemical mixture, is less considerable. For this reason the whitish grey colour of



of that stone is brighter, its thin lamellas more transparent, and, as it appears, the hardness of the stone is in some degree greater.

a) When pounded in the steel-mortar, it afforded a white powder, inclining to pearl-grey. One hundred grains of it, triturated with water in the flint-mortar, I found, after drying and ignition, to have increased 11 grains in weight.

b) Upon these 100 grains, four ounces of caustic lixivium, containing one half its weight of caustic alkali, were affused in the silver crucible; and the fluid evaporated to dryness. The mass being then ignited for three hours, with the necessary precaution, it was again softened by drenching it with water, and afterwards filtered. There remained a grey-white residue, weighing 47 grains when dry.

c) The alkaline fluid (b) let fall, during saturation with muriatic acid, a copious, white, and loose earth; which was immediately re-dissolved by a slight excess of the acid.

d) The above-mentioned 47 grains of earth (b) completely dissolved in the muriatic acid. When this solution was mixed with caustic ammoniac, it afforded a slimy and very puffy precipitate. Mild ammoniac was then added to the liquor, which had been immediately separated from this precipitate by filtering, but it produced no farther precipitation.

e) I then put into caustic lye the slimy precipitate (d), moist as it was, and digested them together. The mixture assumed the appearance of a thickish solution of gum-arabic. On adding more caustic lye, the whole was dis-



solved into a limpid liquor, except some brown flocks, which, in the dry state, consisted of  $2\frac{1}{4}$  grains.

f) Muriatic acid being affused upon this flocculent precipitate (e), a small portion of *siliceous earth* separated, and caustic ammoniac precipitated from the clear solution an *oxyd of iron*, weighing, after ignition,  $1\frac{1}{4}$  grain.

g) From the alkaline solution (e), the muriatic acid threw down a quantity of slimy earth, which was entirely redissolved by a small over-proportion of that acid.

h) Both the solutions (g) and (c), were next united and precipitated by carbonated pot-ash in a boiling-heat, and the dried precipitate was again dissolved in dilute sulphuric acid. When this solution, after the addition of a sufficient quantity of vegetable alkali, had been evaporated to the point of crystallization, it readily afforded clear and regular crystals of alum, or sulphat of alumine.

i) The remaining part of the solution in sulphuric acid (b) thickened spontaneously to a clear jelly, on subsequent evaporation. This gelatinous matter, after being digested with an abundant quantity of water, and repeatedly agitated, again liquefied by degrees. Upon this, some *siliceous earth* subsided; which, when separated by means of a filter, dried up in a raised temperature, in the form of transparent shining grains. It was levigated, together with the foregoing (f), and once more boiled with sulphuric acid. When dried again, and subjected to a red-heat, its weight amounted to  $15\frac{1}{2}$  grains.

k) The above solution in sulphuric acid (i), was then evaporated for further crystallization. It continued to the end to yield successively regularly crystallized sulphat of



alumine: but the very last portion was still contaminated with *siliceous earth*, amounting to 1 grain after ignition.

2) All these several portions of alum were dissolved in water, and precipitated in a boiling heat by carbonat of pot-ash: and when the earthy precipitate which they afforded had been depurated by means of acetic acid, as explained in the preceding section, they gave  $89\frac{1}{2}$  grains of ignited *aluminous earth*.

Therefore, the products obtained by the decomposition of the *Adamantine Spar from Bengal* consist of

Alumine . . . . l) . . . . 89,50

Oxyd of iron . . . . f) . . . . 1,25

Silex . . . . . i)  $15\frac{1}{2}$

k) 1

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$16\frac{1}{2}$

Subtract a) 11

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Remain .  $5\frac{1}{2}$  . . . 5,50

---

96,25

Loss . . . 3,75

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100

The very predominant proportion of the aluminous over the siliceous earth, exhibited by this decomposition of both varieties of the adamantine spar, affords a new proof, that alumine is susceptible of a greater cohesive power than silex is possessed of. Hence nature may form stones of extreme hardness almost entirely from aluminous earth; of which my

lysis of the *Sapphire* will give, in the sequel, a very striking instance. On the contrary, it is evident that this does not hold good with respect to the siliceous earth, as appears from *rock-crystal*, its purest form; for, how inferior is this last in hardness to the sapphire, as well as to the adamantine spar!

On analysing the Chinese adamantine spar, we find that it was siliceous earth that remained, when muriatic acid was poured upon that portion, which was not dissolved by the alkali during ignition. But, on analysing the Bengal diamond-spar, this earth did not appear before the solution of the aluminous earth in sulphuric acid was prepared for crystallizing by evaporation; and at that period this acid caused it to coagulate into an uniform, colourless, gelatinous substance. This last circumstance is frequently attended by a phenomenon which seldom occurs, and is quite different from those which we usually observe on the efflorescing of salts. It is, that the mass, when coagulated to a clear jelly, branches out in several places, and forms separate, unconnected figures, often in the shape of four, five, and six, sided longish pyramids, and often merely as conical points.

Similar phenomena take place, whenever the aluminous earth has entered into intimate union with a small portion of the siliceous, as will be seen by the following experiment:—I mixed 2 drachms of liquor of flints, the siliceous earth of which amounted to 10 grains, with 2 ounces of a solution of alumine in caustic lye; and saturated the mixture with muriatic acid. The earth, thus precipitated, again dissolved into a limpid liquor, on the affusion of a small excess of acid. When a second time precipitated by carbonat of pot-ash, and dried, it weighed 70 grains. I then poured upon it dilute sulphuric acid, and found it entirely dissolved, without depositing the siliceous earth with



with which it was combined. After being in some degree evaporated, part of the solution shot into separate crystals of alum; and the remaining part coagulated in the form of a clear jelly, on the surface of which, after some days, crystalline pyramids sprouted out. And when I had afterwards digested this jelly with a large quantity of water, the filiceous earth subsided; and, being washed and ignited, it weighed again very nearly 10 grains.

However, this jelly, which is frequently colourless, and is formed by a solution of sulphat of alumine, in intimate chemical combination with finely dissolved filiceous earth, and gently evaporated, should not be confounded with the coagulum, which always takes place, whenever the solution of aluminous earth in sulphuric acid has not been blended with the quantity of pot-ash requisite to the formation of perfect crystals. This last forms an opaque mass, of a foliated texture, and soft, greasy consistence.

It yet remained to enquire into the causes which rendered my first analysis of the adamantine spar so very difficult. That one-day is improved by another, is a truth which any attentive chemist has often had opportunity to experience in a very conspicuous manner. The method of preparing hard species of stones, recommended by *Marggraf*, *Bergmann*, and others, in order to weaken the cohesion of their parts, consists in igniting them, mingled with a mild fixed alkali. But when I observed, that this way of preparing them would not answer the purpose in most of the stones belonging to the class of gems; and when I considered that, in the strict sense, it was only the portion of alkalis free from carbonic acid, which is active in this operation, I tried to substitute caustic alkalis to the carbonated, and found that, by their assistance, I attained my end with greater facility and certainty. The application

caustic alkalis, in the dry state, is, nevertheless, attended with several inconveniences. One, and not the least of them, is, that by tritulating them with the body to be subjected to analysis, no very accurate mixture will be obtained. Another circumstance, which embarrassed my first analysis of the adamantine spar, is, that in every attempt I subjected it to ignition in a brisk fire, with the view of ascertaining immediately the quantity of any portion which remained undissolved, or which was precipitated from its solution. But in this way the stone was rendered progressively more incapable of farther solution; and not only its solubility, in so far as it had been promoted by ignition with alkali, but also the advantage obtained in lessening the cohesive force of its constituent parts, have been again lost.

How greatly the decomposition of the harder gems is promoted by the use of caustic fixed alkalis in the liquid state, combined with the other requisite methods of treatment, may be proved by the second analysis of both the Chinese and Bengal adamantine spars.

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## IV.

## EXAMINATION

OF THE

## ORIENTAL SAPPHIRE.

IT seems to be yet doubtful, whether the modern *sapphire* be the same gem which the ancients have denoted by this name. For we do not perceive in our sapphire the disseminated golden points, mentioned by them as one of its essential characteristic marks; whence *Theophrastus*\* calls it *χρυσόπαρος*, and *Epiphanius*†, *χρυσοσπυρίς*. It is, however, certain, from a passage of *Pliny*, that the ancients did not understand by it the *zavos*, or *lapis lazuli*, which usually contains interspersed speckles of a golden lustre; but they have well distinguished both species of stones. *Inest ei (Cyano) aliquando et aureus pulvis, non qualis in sapphirinis. Sapphirus enim et aureis punctis collucet.* *Plinius*, libr. 39. c. 9.

The gem that we call *sapphire*‡ is remarkable by its blue colour, which is so very pleasing to the eye, by its extreme hardness, and the high brilliancy which it shews when polished. Its specific gravity I have found to be 3,950, in those

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\* de Lapidibus.

† de XII. gemmis, quæ erant in veste Aaronis.

‡ For the sake of the less informed, I add, (perhaps not quite superfluously) that the fossil, which is sold by Dutch druggists

those specimens, which were the subject of the following analysis, and consisted of clear, longish-round, abraded grains, of a pure azure colour.

According to the statement of the constituent parts of the sapphire hitherto given, and grounded on *Bergmann's* analysis, an hundred parts of it are said to contain :

|    |                 |
|----|-----------------|
| 35 | <i>Silex</i>    |
| 58 | <i>Alumine.</i> |
| 5  | <i>Lime.</i>    |
| 2  | <i>Iron.</i>    |

But the following analysis, begun and ended with the greatest possible accuracy and precaution, will shew that the above statement was very incorrect.

a) *Hundred* grains of sapphire, previously pounded to a moderately fine powder in a polished steel mortar, were most finely triturated with water in a grinding-dish of flint. When this sapphirine powder had been dried, carefully collected, and ignited, I observed, that its weight had increased  $12\frac{1}{2}$  grains from the siliceous earth of the grinding vessel.

b) Two ounces of muriatic acid were poured upon these  $112\frac{1}{2}$  grains in a phial so as to cover them, and the whole was repeatedly digested with a moderate heat. The filtered acid, mixed with the edulcorating water, was then

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for *sapphire*, in the shape of small, heavy, black-grey, and internally resplendent grains, and which, since the belief in the medicinal virtues of gems, has lost ground, is now kept in the shops merely as an useless drug, is nothing else but *magnetic octahedral iron*, which in Ceylon accompanies the sapphire, hyacinth, and other gemmeous strata, and, together with those stones, is collected by washing off the sand.

saturated,



saturated, in a boiling heat, with mild alkali prepared from tartar, by which there separated yellow flocks, weighing two grains when dry. These being again dissolved in muriatic acid, and precipitated by caustic ammoniac, I transferred the precipitate, while yet moist, into boiling caustic lixivium. It deposited *oxyded iron*, which, after ignition, weighed *half* a grain. The aluminous earth, taken up by the caustic lye, was again separated from it, and found to weigh *one* grain.

c) After this extraction by muriatic acid, as much caustic lye was affused on the sapphirine powder, placed in the silver crucible, as was necessary to make the caustic alkali, contained in it, amount to six times the weight of the powder. It was next evaporated in a sand-heat, till the mass was dry; upon which the crucible was placed in the furnace, surrounded with charcoal, and subjected to a red heat for two hours. The contents of the crucible returned from the fire in the form of a whitish, loose, and friable mass.

d) This mass was softened with hot water, and put on the filter. There remained a bluish-grey, slimy residue, which, being dried, gave a powder of little cohesion, weighing  $34\frac{1}{2}$  grains. On adding muriatic acid, it readily dissolved; but congealed soon after to a turbid jelly. By dilution with water, and digestion, some earthy particles were deposited, which, after washing and drying, amounted to 14 grains.

e) When these flocculent particles had been removed, the muriatic solution was saturated with caustic ammoniac; and the result was an intumesced, transparent precipitate, which, being previouslyedulcorated, was digested, while yet moist, in caustic lye. It readily dissolved in it; with  
the

the exception of a few brown flocks, which, when collected and ignited, weighed one fourth of a grain, and were oxyd of iron.

*f*) The alkaline solution (*e*) was decomposed by muriatic acid; and the precipitate which it afforded re-dissolved by a slight excess of that acid. Upon this, the earth was again precipitated by mild vegetable alkali, in a boiling heat. The weight of the earth obtained in this part of the process was 16 grains, after it had been washed and dried.

*g*) In the same manner I combined with muriatic acid the preceding alkaline solution (*d*), obtained by softening the ignited mass. There resulted from it a copious white precipitate; but which was again totally dissolved, by a slight over-saturation with muriatic acid. The earth was then precipitated afresh by mild vegetable alkali, assisted by a boiling heat; and was found to weigh 289 grains, when washed and desiccated.

*h*) To this earth I added the above 16 grains (*f*), as also the one grain of (*b*); and poured upon the whole dilute sulphuric acid. The solution, which was easily brought about in a moderate temperature, again deposited *eight grains* on cooling.

*i*) These eight grains, together with the 14 of (*a*), being then mixed with six times its quantity of caustic lye, were inspissated, and heated to redness. The mass, thus obtained, and afterwards liquefied in water, left, on filtering, a grey residue, weighing 17 grains after desiccation, which soon were dissolved by the affusion of sulphuric acid, leaving some few, inconsiderable particles behind. The alkaline solution, when saturated with muriatic acid, continued

at



at first limpid; but it deposited *four grains* of filiceous earth, when evaporated in a warm temperature.

k) I now mixed the solutions in sulphuric acid, mentioned at (b) and (i); added to them a proportional quantity of carbonated pot-ash, and, by gentle evaporation, caused them to shoot into crystals. At first, fine, pure, and regular crystals of sulphated alumine were formed: but the remaining liquor, while further evaporating, congealed into a clear, gelatinous matter, without any diminution of its transparency. Having poured upon it a quantity of water, I subjected it to continued digestion, stirring it now and then. By this management I effected the thorough separation of the finely divided filiceous earth, which was the cause of the coagulation; inasmuch, that I was enabled to collect it on a filter. This *filiceous earth*, carefully collected, together with the above four grains (i), weighed  $11\frac{3}{4}$  grains.

l) The remaining sulphuric solution, freed from its filiceous contents, was now set to crystallize. However, the last portions of alum indicated, by their lemon-yellow tinge, that they still contained some metallic substance. In consequence of this, I re-dissolved them in water, together with the few residual drops of their mother-liquor, and combined them with prussiat of pot-ash (blood-lye). A blue precipitate subsided; but in so small a quantity, that the *portion of iron*, thus separated, could hardly be estimated at one fourth of a grain. The supernatant fluid, freed from it, afforded pure sulphat of alumine to the last drop.

m) The crystals of alum, obtained in the several foregoing operations, being dried on a porcelain saucer in open air, amounted in the whole to 856 grains. They were then dissolved in boiling water, decomposed by carbonat of pot-

pot-ash in the heat of ebullition, and the precipitated earth wasedulcorated and dried. But, in order to free this earth perfectly from those saline particles, which still adhered obstinately, and augmented its weight, I subjected it to gentle digestion, with six ounces of distilled vinegar. Which done, I neutralized the acetic acid by caustic ammoniac;edulcorated afresh the *aluminous earth*, then precipitated, and lastly, exposed it to a brisk red-heat, after drying. It weighed now  $98\frac{1}{2}$  grains.

n) It still remained to examine theedulcorating water. Being evaporated to dryness, and the residue re-dissolved in little water, there remained a slight portion of grey earth, which, when examined by sulphuric acid, proved to be calcareous. The solution yielded, during evaporation, selenitic crystals; which, when carefully collected, weighed  $1\frac{1}{2}$  grain, the *calcareous earth* of which should be estimated at one half grain.

What principally demands our consideration, in the result of this analysis, is the remarkable and unexpected circumstance of the total absence of the siliceous earth, from among the constituent parts of the sapphire. For the  $11\frac{1}{2}$  grains of filix which were obtained (*k*), must undoubtedly be ascribed merely to the flinty triturating vessel, from which the sapphire had, on grinding, abraded  $12\frac{1}{2}$  grains (*a*), and at the same time had united with it so intimately, that I could not recover it without great difficulty, and even not without a small loss of three fourths of a grain.

Hence, the following alone can be reckoned among the constituent parts of the sapphire, procured by decomposition:



|                                     |       |
|-------------------------------------|-------|
| Alumine . . . . .                   | 98,50 |
| Oxyd of iron b) . . . $\frac{1}{2}$ | }     |
| c) . . . $\frac{1}{4}$              |       |
| l) . . . $\frac{1}{4}$              |       |
| Lime . . n) . . . . .               | 0,50  |
|                                     | <hr/> |
|                                     | 100.  |

Since on analysing fossils, even with the most cautious management, there is always some unavoidable loss, it is probable, that the present perfect agreement of the sum of these constituent parts, with the original weight of the sapphire employed, is merely accidental. And the reason of this agreement must be sought for, in the variable state of dryness, communicated to the aluminous earth by heating it to redness.

Whence, subtracting the unimportant, and perhaps only casual portion of calcareous earth, as well as the slight quantity of ferruginous matter, we find in the sapphire, the nature of which is now developed, nothing else than a simple aggregate of pure aluminous earth.

But, what a high degree of cohesive power, and most intimate chemical combination, must nature be able to command, in order to be capable of transforming such a common substance, as the *aluminous earth*, into a body, so eminently distinguished and ennobled, as we find the *sapphire* to be, by its hardness, density, brilliancy, and resistance to the actions of acids and fire, as well as to natural decay in the course of all-consuming time!—It is, therefore, not the *identity*, or precise sameness of the constituent parts alone, but also the *peculiar nature of their chemical combination*, which constitutes the *metaphysical essence* of the products formed from them by nature.

## EXAMINATION

OF THE

## CAT'S-EYE.

THE species of precious stones, known by the name of *Cat's-eyes*, has received that denomination from its property of reflecting, in certain directions, a changeable whitish effulgence, in which it resembles the eyes of a cat.

As this stone is still a rarity in Europe, the description of its external characters, met with in the latest introductions to Mineralogy, could only be taken from the polished specimens which are brought to us from *Ceylon*. As I have in my collection rough cat's-eye from the coasts of *Malabar*, for which I am indebted to the kindness of *Francis Greville*, Esq. in London, and which, besides, is one of its more unusual varieties, I think the following addition to the descriptions of its external characters, already published, will not be useless.

The largest specimen consists in a fragment, notably quadrangular, of *one* inch in *length*, three-fourths of an inch in *breadth*, three-fourths ditto in *height*, and three and a half drachms in weight. Its cross-fracture exhibits a brown-red colour of various shades, a moderate greasy lustre,



lustre, and minute sharp-edged prominences. On the longitudinal fracture, its colour is lighter, its lustre stronger, and it reflects variegated yellowish rays of light; at the same time, that an imperfectly foliated texture, spreading in various directions, is perceivable. On two contiguous sides it still retains its natural surface, or crust, which is formed lengthways of convex, roundish striæ; and its colour, which was at first brown-red, has faded into a dull brownish-yellow. Its edges and small splinters alone are faintly transparent.

I found the specific gravity of this rough cat's-eye to be 2,625; whereas that of the whitish, greenish, and yellowish specimens from Ceylon is 2,660.

In the *Essay on the Habitudes of several Stones and Earths in strong Fire*, I have already shewn that the cat's-eyes are perfectly infusible in the strongest degree of heat produced in the porcelain-furnace; therefore I shall at present mention only the change which they undergo in a weaker fire. For this purpose I ignited to redness in a crucible some of the common polished cat's-eyes, of a greenish and greyish-white colour, and quenched them in cold water. I found them afterwards absolutely unaltered in form, hardness, and splendour; but they were rendered totally opaque, and acquired an extremely fine marbled jasper-like appearance, variegated with brown, reddish, grey, and white spots.

---

A.

a) Two hundred grains of finely levigated *Cat's-eyes* from Ceylon, were mingled with 400 grains of carbonat of soda (mild

(mild mineral alkali), and the blended mass was exposed in a silver-crucible to gentle ignition for four hours, but without urging the heat to fusion. In the next place I softened the mass with water; saturated it to excess with muriatic acid; and suffered it to stand for some time in digestion. A considerable quantity of *siliceous earth* then separated, which was collected on the filter, washed, dried, and lastly exposed to a strong red-heat. In this state it weighed 189 grains.

b) The muriatic solution, mixed with the edulcorating water, and concentrated by evaporation, was saturated while yet hot with carbonated soda; and I obtained a precipitate, which, when washed and dried, weighed 15 grains.

c) These entirely dissolved, with effervescence, in the muriatic acid. Only a slight portion of *siliceous earth* remained, which after ignition amounted to one grain.

d) After the grain of siliceous earth had been separated, caustic ammoniac was added to the solution. A yellowish-white, slimy precipitate was thrown down; which being immediately separated by filtration, washed, and afterwards dissolved, while yet moist, by caustic lye, left behind an *oxyd of iron*, weighing one half grain, when washed and ignited.

e) I then, by means of muriatic acid, separated the earth taken up by the caustic lye; but being re-dissolved by a slight excess of this acid, it was again precipitated by carbonat of soda. When edulcorated, and dissolved in sulphuric acid, it shot into crystals of *alum*. This sulphat of alumine was then dissolved in water, and its earth again precipitated.



V. Examination of the Cat's-Eye. 81

precipitated by carbonat of soda. This alumine, when edulcorated, and ignited after desiccation, was found to weigh  $3\frac{1}{2}$  grains.

f) The liquor which remained, after the precipitation had been effected by caustic ammoniac (d), was then combined in a warm temperature with mild mineral alkali; by which treatment, *calcareous earth* subsided, which formed selenite (sulphat of lime) with sulphuric acid. The lime thus separated from this compound, and ignited, weighed three grains.

Since, therefore, 200 grains of these cat's-eyes afforded

|              |    |     |   |                |
|--------------|----|-----|---|----------------|
| Silex        | a) | 189 | } | 190            |
|              | b) | 1   |   |                |
| Alumine      | e) |     |   | $3\frac{1}{2}$ |
| Lime         | f) |     |   | 3              |
| Oxyd of iron | d) |     |   | $\frac{1}{2}$  |
| <hr/>        |    |     |   |                |
|              |    |     |   | 197 grs.       |

it follows, that it contains in *one hundred*,

|              |       |
|--------------|-------|
| Silex        | 95    |
| Alumine      | 1,75  |
| Lime         | 1,50  |
| Oxyd of iron | 0,25  |
| <hr/>        |       |
|              | 98,50 |
| Lofs         | 1,50  |
| <hr/>        |       |
|              | 100   |

G

B a)

## B.

a) Hundred grains of the crude red cat's-eye from Malabar, described as above, yielded a grey friable mass; after being finely pulverized, mingled with 300 grains of caustic pot-ash, and ignited, but without fusion, for an hour in the silver crucible. It soon dissolved in water, and formed a turbid liquor. Upon super-saturating it with muriatic acid, and subsequent digestion and filtration, there remained a delicate, white *siliceous earth*, which, after washing and drying, amounted to 115 grains, but after half an hour's ignition weighed only 93 grains.

b) The muriatic solution (a), mixed with the washings, and previously concentrated by evaporation, was then precipitated by carbonated pot-ash, in the heat of ebullition. The yellowish precipitate, which subsided, weighed  $8\frac{1}{2}$  grains after deficcation.

c) These  $8\frac{1}{2}$  grains completely dissolved in muriatic acid. Caustic ammoniac threw down from this solution a slimy earth; which only partially dissolved in the caustic lixivium, with which it had been digested, and left five grains on the filter.

d) When the earth, taken up by the caustic alkaline lye, had again been separated from it, and washed and ignited, its weight amounted to two grains. It also afforded *crystals of alum*, on being treated with sulphuric acid.

e) The above five grains (c), digested with sulphuric acid, still deposited *siliceous earth*, which, having been exposed



posed to a red-heat, weighed  $1\frac{1}{2}$  grain. The solution, freed from this earth, while evaporating, yielded *selenite-crystals*. The yellowish liquid, rinsed off from them with dilute or weak ardent spirit, and combined with prussiat of pot-ash, produced a deep blue precipitate; the quantity of which was so small, that the *oxyd of iron* thus indicated, could not with propriety be estimated higher than at one fourth of a grain. Mild alkali still separated from the remaining liquor an inconsiderable portion of alumine.

f) Mild vegetable alkali, added at a raised temperature to the fluid, from which the caustic ammoniac separated the above-mentioned muddy precipitate (c), threw down another portion of earth, which united with sulphuric acid into sulphat of lime. The *calcareous earth* contained in this selenite, as also in that of (c), was reproduced, or separated from its accompanying acid, by boiling with a solution of mild alkali; and its quantity was found, after ignition, to amount to  $1\frac{1}{2}$  grain.

According to this analysis, the constituent parts of this red variety of cat's-eye, consist in the *hundred* of

|                     |   |   |   |   |   |    |   |                |   |       |       |
|---------------------|---|---|---|---|---|----|---|----------------|---|-------|-------|
| <i>Silex</i>        | . | . | . | . | . | a) | . | 93             | } | .     | 94,50 |
|                     |   |   |   |   |   | c) | . | $1\frac{1}{2}$ | } | .     |       |
| <i>Alumine</i>      | . | . | . | . | . | d) | . | .              | . | .     | 2,    |
| <i>Lime</i>         | . | . | . | . | . | f) | . | .              | . | .     | 1,50  |
| <i>Oxyd of iron</i> | . | . | . | . | . | e) | . | .              | . | .     | 0,25  |
| <hr/>               |   |   |   |   |   |    |   |                |   |       |       |
|                     |   |   |   |   |   |    |   |                |   | 98,25 |       |
|                     |   |   |   |   |   |    |   |                |   | Lofs  | 1,75  |
| <hr/>               |   |   |   |   |   |    |   |                |   |       |       |
|                     |   |   |   |   |   |    |   |                |   |       | 100   |

34 V. *Examination of the Cat's-Eye.*

Therefore, this *proportion of the constituent parts*, which in both varieties is to be considered as perfectly constant, together with their *absolute infusibility*, (not to mention the difference in the external character) afford sufficient reason for distinguishing *cat's-eye* from *fel-spar*, under which this fossil has been classed by several Mineralogists.—On the contrary, it would be more proper, in my opinion, to class it with the opals; among which also it was formerly reckoned under the names of *Pseudopal*, *Cat's-eye-opal*.

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## VI.

## ANALYSIS

OF

## CHRYSOBERYL.

THE *Chrysoberyl*, found in the Brasil, passed for a variety of the *Chrysolite*, until M. *Werner*, Counsellor of the mines, was induced, by a more accurate comparison of their respective external characters, to separate the former from the latter; and to range it in the mineralogical system as a distinct species, with its present denomination. This *Chrysoberyl*, however, must not be mistaken for the *Chrysoberyl of the ancients*, which really was the substance indicated by this name; that is to say, the *golden-yellow beryl*; as may be concluded from its description, given by *Pliny*. Libr. XXXVII. Cap. V. *Probatissimi sunt ex iis, (namely Beryllis), qui viriditatem puri maris imitantur. Proximi, qui vocantur Chrysoberylli, et sunt paulo pallidiores, sed in aureum colorem exeunte fulgore.*

The modern *chrysoberyl* has hitherto been met with only in shivery, loose, rounded grains\*, of the size of smal-

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\* *Geschiebe* in German. *Rachill* by the miners; or such loose, small, shivery stones, as most commonly lie on the top of the rock, or immediately under the vegetable earth. See *Hoozon's Miner's Dictionary*.—Transl.

ler and larger peas, of a pale-yellow colour, insensibly verging to green. The surface of these grains, which is somewhat rough, strongly glitters, and usually reflects variegated colours, like moonstone (*adularia*). But the fracture of chrysoberyl possesses a great splendour, which, in conjunction with a very considerable hardness, gives it a high brilliance when polished: and hence it may easily be confounded with the yellow diamond. Some few specimens exhibit some remaining traces of an originally crystalline figure.

The specific gravity of this stone I have found to be 3,710; which therefore agrees with that mentioned by *Werner*, from 3,698 to 3,719, and is precisely the mean between these two extremes.

The first analytical attempts upon it, which I made before I was acquainted with those skilful processes which I learned from later experiments, gave me a good deal of trouble, and at the same time destroyed a considerable part of my stock of these stones. But I pass them over, and confine myself merely to that analysis, the result of which was the complete decomposition of the chrysoberyl.

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*a)* Hundred grains of chrysoberyl, previously reduced to a moderately fine powder, by pounding them in a mortar of polished steel, were levigated with water to perfect fineness in the flint grinding-dish. After the powder had become dry, I subjected it to gentle ignition, for the purpose of freeing it from all moisture. However, its weight was increased 13 grains.

*b)* Upon these 113 grains, introduced into a silver-crucible, I poured so much caustic lixivium, that the proportion  
of



of alkali which it contained amounted to 800 grains, and evaporated the liquid again till the mass was dry. Upon this I placed the crucible with its contents in a wind-furnace, on a stand of porcelain clay, surrounding it with coals. Attention was carefully paid to prevent the mass, which greatly swelled in bulk, from flowing over the vessel. The heat applied was at first rather low; but it was gradually urged until the mass became red-hot. In this degree of heat it was kept for two hours; but it did not enter into actual fusion.

c) When this mass had cooled in some degree, I softened it in the crucible with water, and poured the solution upon the filter. When the fluid parts had passed through, there remained on the paper a loose, light-grey powder, which, whenedulcorated and dried, weighed  $66\frac{1}{2}$  grains.

d) The alkaline lye that had been separated, together with theedulcorating water, was first evaporated, to lessen its bulk, and then saturated with muriatic acid. An abundant white precipitate fell down, but was instantly and clearly re-dissolved, by a small excess of acid. Carbonat of pot-ash, added over a low fire, again precipitated this earth; which being washed, and dried in a gentle warmth, was loose, as white as snow, and weighed  $138\frac{1}{2}$  grains.

e) The light-grey pulverulent residue, mentioned at (c), amounting to  $66\frac{1}{2}$  grains, being digested with muriatic acid, left again a residue; which, after washing, drying, and ignition, weighed  $24\frac{1}{2}$  grains, and was found, upon farther examination, to be pure *siliceous earth*.

f) This muriatic solution (e), separated from the filix, was next decomposed, in a boiling heat, by means of caustic ammoniac, and the yellowish precipitate, thus produced, wasedulcorated; and, while yet moist, was boiled with

caustic lye. It entirely dissolved therein, some brown particles excepted. This residue was *oxyd of iron*, and weighed, after ignition in a gentle heat,  $1\frac{1}{2}$  grain.

g) The alkaline solution (*f*) was saturated with muriatic acid. The result of this process was a white precipitate, which, by a slight supersaturation, again formed a limpid solution. The earth was then a second time precipitated, by boiling with mild vegetable alkali. Its weight amounted, after desiccation, to 29 grains.

h) These last 29 grains, together with the preceding  $138\frac{1}{2}$  grains of earth (*d*), to which I also added the two grains, which were collected from the edulcorating water by evaporation, were digested with diluted sulphuric acid. The whole was dissolved, excepting some *siliceous earth*, which weighed 4 grains after ignition.

i) When this solution, now perfectly clear, was a little evaporated at a low temperature, tender, spicular, or spear-shaped crystals, gradually separated from it; which I collected with proper care. They presented all the marks of selenite; and, on decomposition by a solution of carbonat of pot-ash, in boiling heat, they afforded 11 grains of mild *calcareous earth* (carbonat of lime). This calcareous constituent part of the chrysoberyl was, doubtless, before contained in the precipitate of (*d*); and, previous to its falling down, it was held in solution merely by the water, as it was then in the caustic state.

k) This sulphuric solution I now combined with the proportion of carbonated pot-ash requisite to the formation of alum\*; which shot, by degrees, into regular crystals.

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\* On the necessity of pot-ash, and its proportion in the formation of alum, see *Hildebrandt's paper in Nicholson's Journal*, vol. IV. page 49.—Transl.



# VI. *Analysis of Chrysoberyl.* 89

Towards the end, however, a slight portion of *siliceous earth* appeared, which, after ignition, was not more than  $2\frac{1}{2}$  grains. The weight of all the sulphat of alumine obtained amounted to 604 grains.

1) This alum was again re-dissolved in boiling water, and afterwards decomposed by means of carbonat of potash, at the heat of ebullition. After the precipitated earth had been washed, dried, and gently ignited, I digested it with distilled vinegar; which being neutralized by caustic ammoniac, the earth was again precipitated by this treatment, and again washed, desiccated, and heated to redness. It proved now to be perfectly pure *aluminous earth*, weighing  $71\frac{1}{2}$  grains.

We may, therefore, infer, that the constituent parts of the chrysoberyl, exhibited by this analysis, consist in the *hundred*, of

|                     |   |   |   |   |    |    |               |   |   |       |
|---------------------|---|---|---|---|----|----|---------------|---|---|-------|
| <i>Alumine</i>      | . | . | . | . | l) | .  | .             | . | . | 71,50 |
| <i>Lime</i>         | . | . | . | . | i) | .  | .             | . | . | 6     |
| <i>Oxyd of iron</i> | . | . | . | . | f) | .  | .             | . | . | 1,50  |
| <i>Silex</i>        | . | . | . | . | e) | 24 | $\frac{1}{2}$ |   |   |       |
|                     |   |   |   |   | b) | 4  |               |   |   |       |
|                     |   |   |   |   | k) | 2  | $\frac{1}{2}$ |   |   |       |

|                  |    |    |    |
|------------------|----|----|----|
|                  |    |    | 31 |
| To be subtracted | a) | 13 |    |

|        |   |    |   |   |   |       |
|--------|---|----|---|---|---|-------|
| Remain | . | 18 | . | . | . | 18,00 |
|--------|---|----|---|---|---|-------|

|      |     |
|------|-----|
|      | 97  |
| Loss | 3   |
|      | 100 |

From

From comparing the present analysis of *chrysoberyl* with the following decomposition of *chrysolite*, it is evident how greatly their respective constituent parts differ, and consequently, how necessary it was to separate them from each other, in the systematical arrangement of the species of gems.

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## VII.

## EXAMINATION

OF

## CHRYSOLEITE.

THE *Chrysolite* affords a singular instance of change in names; since, at present, we call the same gem *Topaz*, which the ancients understood by the denomination *Chrysolite*; for it is evident, from the following words of Pliny, that the *Topazius* of the ancients is not our modern *Topaz*; but, on the contrary, the *Chrysolite* of the present times: *Ejus tota similitudo ad porri succum dirigitur. Est autem amplissima gemmarum. Eadem sola nobilium limam sentit: cætera Naxiis cotibus poliuntur. Haec et usu atteritur.* Pliny Hist. Nat. Lib. XXXVII. Cap. VIII.—The cause of this change of name is so much the more unaccountable, as the denomination *Chrysolithus* (golden-stone) undoubtedly more applies to the *Topaz*, which is of a golden-yellow colour, than to our *Chrysolite*, which is green.

The more detailed external description of the *Chrysolite*, given by *Werner*\* with that degree of accuracy we are en-

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\* *Bergmännisches Journal*, 3d year, 1790, Vol. 2, page 54.

titled to expect from such a master, comprehends all, that, in the present state of our knowledge, can be said on the natural history of that stone, respecting its external characters, and the marks by which it is to be distinguished from the other species of stones, with which it has been so often confounded. But, on the other hand, an accurate chemical analysis, and hence also the knowledge of its proper place in the mineralogical system, have, till now, been so much the more wanting : a deficiency which I hope to remove, by now publishing the experiments to which I have subjected it.

To remove all doubts, I previously mention that the Chrysolites analysed by me, as well as those from which *Werner* has drawn up their external description, were bought by *John Hawkins*, Esq. in the Levant, on his travels for promoting the knowledge of Natural History, and were sent to me by him for that purpose.

The specific gravity of Chrysolites I have found to agree with the statement of *Werner*, namely, 3,340.

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A.

a) I took *two hundred* grains of rough chrysolite, and at first bruised them in the steel-mortar, and afterwards reduced them to a fine powder by trituration with water in the flint grinding-dish. This powder, when dried by heat, I observed had not increased in weight. I poured upon it *two ounces* of pure caustic lye, the alkaline contents of which amounted to one half of its weight, and evaporated the whole to dryness in the silver-crucible, and ignited



nited it afterwards for thirty minutes. There remained a friable mass, which, after cooling, was of a dusky olive-green.

b) When this mass had been softened with water, the solution assumed the same colour, and a brown, undissolved portion fell to the bottom, of a slimy appearance. The solution being saturated to excess with muriatic acid, and sufficiently digested, acquired a saffron-yellow colour: upon which it was diluted with water, and filtered. A pure siliceous earth then remained, which, after ignition, amounted to  $72\frac{1}{2}$  grains.

c) The muriatic solution, when decomposed in a boiling state by mild vegetable alkali, prepared from tartar, afforded an abundant, light-brown-red precipitate, which, upon desiccation, again entirely dissolved in muriatic acid, and by the affusion of caustic ammoniac, formed a brown-red precipitate; which was directly separated by filtering, then washed, and digested with caustic lye, while yet moist. However, only a small portion seemed to dissolve by this treatment.

d) After the undissolved matter had been separated from the alkaline solution (b), I super-saturated this last with muriatic acid, and added carbonated pot-ash, for the purpose of obtaining a precipitate. However, only a little earth separated, which, when collected, and tried for alumine by sulphuric acid, did not dissolve in it; but, on closer examination, proved to be *siliceous earth*, weighing  $3\frac{1}{2}$  grains after ignition.

e) The brown precipitate, which had been digested with caustic lixivium (c), when dry and exposed to a red-heat, gave 38 grains in weight. It consisted of a pure *oxyd of iron*.

*iron.* The whole was attracted by the magnet. Upon being dissolved in muriatic acid, and again precipitated by prussiat of pot-ash, it yielded 88 grains of very deep-coloured Prussian-blue.

*f)* The muriated fluid, after the ferruginous contents had been separated from it by ammoniac (*c*), gave a copious white and loose earth, by adding carbonat of pot-ash. The mixture having been kept boiling for some time, this earth was separated by filtration, well washed, and dried. It amounted to 198 grains of *carbonated magnesia* (mild magnesian earth), which I divided into two parts. One half of it was strongly ignited for the space of an hour, and left  $39\frac{1}{2}$  grains, which produced a brisk ebullition upon the affusion of sulphuric acid. The other half was introduced into dilute sulphuric acid. It directly afforded a clear solution, and pure sulphat of magnesia (Epsom salt), by crystallization.

*Note.* It was by mere accident that, on the precipitation at (*c*) no more ammoniac had been added than was just necessary to separate the oxyd of iron; since otherwise, in all cases, the magnesian earth is also precipitated by ammoniac.

According to this decomposition, the constituent parts of the chrysolite should be in the *hundred*,

|                             |           |           |                 |   |       |               |
|-----------------------------|-----------|-----------|-----------------|---|-------|---------------|
| Ignited <i>Silex</i>        | . . .     | <i>b)</i> | $36\frac{1}{4}$ | } | . . . | 38            |
|                             |           | <i>d)</i> | $1\frac{3}{4}$  | } |       |               |
| Ignited <i>Oxyd of Iron</i> | <i>e)</i> | . . . . . |                 |   |       | 19            |
| Ignited <i>Magnesia</i>     | <i>f)</i> | . . . . . |                 |   |       | 39,50         |
|                             |           |           |                 |   |       | <hr/>         |
|                             |           |           |                 |   |       | 96,50         |
|                             |           |           |                 |   |       | Lofs . . 3,50 |
|                             |           |           |                 |   |       | <hr/>         |
|                             |           |           |                 |   |       | 100           |



## B.

For a second analysis of chrysolite I chose polished specimens, which, besides a pure transparency, possessed also a brighter colour: whereas the crude chrysolites, employed in the foregoing process, were in some parts inclining to brown. As I intended, at the same time, to learn whether acids alone were capable of decomposing this stone, without previous treatment with alkali, I made use of the sulphuric acid, according to the manner in which *Marggraf* has employed it for decomposing the serpentine.

a) I poured ten drachms of concentrated sulphuric acid, mixed with double that quantity of water, upon *two hundred* grains of most finely-powdered chrysolite, placed in a retort, and abstracted again the fluid, in a moderate distilling heat, until the remainder in the retort appeared a dry mass. The liquor which came over, emitted a moderate sulphureous smell. When cold, I collected the mass from the retort, the upper part of which I cut off, and lixiviated it with boiling water. The solution exhibited a greenish-colour, but so faint as to be hardly perceptible.

b) The undissolved residue was boiled a second time, in a matras, with two drachms of concentrated sulphuric acid, and two ounces of water. After this it was again collected on the filter, washed with an abundance of boiling water, desiccated, and heated to redness. It proved to be pure, white *siliceous earth*, weighing 78 grains.

c) Both the sulphuric solutions (a) and (b) were evaporated to dryness in a porcelain-saucer. The residual mass had a greenish-grey tinge: it was first gently heated

in

in a porcelain pot, during which operation it emitted strong fumes; and after this it was thoroughly ignited in a brisk fire for the space of one hour.

d) The ignited mass had then acquired a brick-red colour. It was levigated, lixiviated with hot water, and the red *oxyd of iron*, which it contained, was separated by filtration, and subjected to ignition. This oxyd weighed 39 grains: but as, in the present state, it was combined with a greater quantity of oxygen than when forming a constituent part of the chrysolite, in order to free it from that excess, it was immersed in melted wax, in a small crucible; and, after the wax had been burnt off, the oxyd was kept for some time longer in a low red-heat, the vessel being then covered. Its red colour had now changed into a blackish brown; it was also readily attracted by the magnet, and weighed 38 grains.

e) After the colourless sulphated solution (d) had been evaporated for crystallization, it yielded, to the last drop, pure sulphat of magnesia. This neutral salt being dissolved, and decomposed in the heat of ebullition by carbonated pot-ash, afforded 213 grains of white and loose *magnesian earth*, the weight of which, after an hour's ignition, was only 87 grains.

From this second analysis, which exceeds the foregoing in the accuracy of its results, it appears that the constituent parts of chrysolite, proportioned to each other in the *hundred*, are as follows:

|                             |          |       |        |
|-----------------------------|----------|-------|--------|
| Ignited <i>Magnesia</i>     | . . . c) | . . . | 43,50  |
| <i>Silex</i>                | . . . b) | . . . | 39     |
| Ignited <i>Oxyd of Iron</i> | . . d)   | . . . | 19     |
|                             |          |       | <hr/>  |
|                             |          |       | 101,50 |

Nett,



Note. The reason why, in the present decomposition, there is a slight excess of weight in the sum of the constituent parts, instead of the usual loss in most other cases, undoubtedly depends in the variable degrees of dryness which those ingredients acquire on ignition.

In the quarries near *Leutschau*, in Hungary, we meet with a pale-green serpentine, mixed with grey, and crossed by tender veins of asbestos. It also contains, copiously disseminated, resplendent grains, of a high green colour, which, in some parts of my specimen, exhibit a rhomboid crystallization. *Born*\* and *Fichtel*†, who have given a more circumstantial information respecting this stone, call these grains *Chrysolite*. *Fichtel*, however, is uncertain whether they should not rather be considered as *Chrysoprase*. But this conjecture is too little favoured by the external characteristic marks; while, on the other hand, the minuteness of these grains, and the impossibility of separating them from the stone, which serves them for a matrix, will not admit of a chemical examination. Notwithstanding this, their presence in the serpentine affords a *geognostic* argument for considering them as chrysolite, since the constituent parts of each have been discovered to be the same.

\*            \*            \*

A loose stony matter (*rachill*), which is found near *Moldauthein*, in Bohemia, has likewise, for some time past, been held out to be chrysolite: but, on judging from the

\* Catal. meth. et raison, de la collect. des Foss. Tom. I. p. 69.

† *Mineralog. Bemerk. v. d. Karpathen*, I. Th. Wien. 1791, page 60, 61.

specimens, rough and polished, which I have seen at *Prague*, I cannot consider them as such; because the external appearance of the rough pieces, and especially the fine air-bubbles observable in the polished specimens, are rather an indication of a volcanic product. Herein I also find the opinion of *Lindacker*\* to agree with mine.

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\* See his *Beitrag zur Geschichte der böhmischen Chrysolithe*: in den *Saml. physikal. Aufsätze besonders die böhm. Naturgeschichte betreffend*. 2 Band Dresden, 1792.

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## VIII.

## EXAMINATION

OF

## OLIVIN.

TO the various stones which were formerly considered as a subordinate species, or rather variety of chrysolite, also belongs the fossil known by the name of *Basaltic*, or *Volcanic Chrysolite*.

On giving the external description of this stone, together with that of the true chrysolite, *Werner* has not only accompanied it with the most instructive observations, but likewise, from his *oryctognostic* inquiries, he has shewn the necessity of distinguishing the *basaltic* from *true* chrysolite. Whence also he considers the former as a distinct species, with the name *Olivin*, taken from its colour.

As it is the office of Chemistry to assist the *Oryctognostic Science*\* in the further improvement of its system, by

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\* By *Oryctognosy*, *Werner* understands the *scientific* knowledge or discrimination of fossils from each other, considered as simple, that is, not compounded aggregates of various different minerals; and their *scientific* arrangement, or *classification*, into a regular system, according to certain *orders*, *classes*, *genera*, *species*, *varieties*, &c.—  
Transl.

communicating certain facts relative to the constituent parts of minerals, it is for the Chemist to examine whether, and how far, the conjectures respecting the essential ingredients in any fossil, inferred from its external properties, are founded in nature: and, consequently, to determine with what propriety it had obtained the place previously given to it in the system, on account of those supposed constituent parts.

For this reason I have thought it expedient to join the analysis of the Olivin with that of Chrysolite.

### FIRST SECTION.

#### *Analysis of the Olivin; from Unkel.*

To discover the constituent parts of Olivin, I first chose that from the *Basalt of Unkelstein*; in which rock it occurs in its perfect and undecayed state, in pretty large clusters, of a thoroughly equal, pale leek-green colour, and without any admixture of extraneous matters. Its specific gravity was 3,265.

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#### A

a) *Two hundred grains* of finely pulverized Olivin were covered with two ounces of caustic lye, the alkaline part of which constituted half its weight. After the liquid had been evaporated, the dry mass was ignited for half an hour.

It



It assumed a grey colour, and was then liquefied or softened with water, and filtered.

b) Upon saturation with muriatic acid, the alkaline lixivium let fall a white earth, which, being collected and dried, was boiled with sulphuric acid. But this earth did not impart any foreign taste to the acid; and when this last had again been decanted off, and saturated with mild alkali, it continued clear. Therefore the above earth was of the pure *siliceous* kind. When ignited, it weighed 49 grains.

c) The ash-grey residue, sepatated from the alkaline lye (a), coagulated to a thickish brown mass, upon the affusion of muriatic acid. After this coagulum had been diluted and digested with sufficient water, there remained a copious, light, slimy, and brown residue, which, upon desiccation, weighed 152 grains.

d) The muriatic solution, separated from this residue by filtration, was colourless. By the addition of mild alkali, prepared from tartar, it was decomposed with the assistance of boiling heat, and 181 grains of a very white, loose earth, were precipitated.

e) When the brown residue, mentioned at (c), after trituration, was digested with muriatic acid, it dissolved into a yellow liquid, leaving, at last, *siliceous earth* behind, weighing 43 grains after ignition.

*Note.* It was undoubtedly this siliceous earth, still intimately united with the ferruginous part of the stone, which in (c) prevented the muriatic acid from exerting its action on the oxyd of iron: yet this circumstance, at the same time, furnished the means of exhibiting, free from iron, that portion of the earth which the acid had dissolved.

f) The ferruginous portion of the yellow muriatic solution (e) I precipitated by caustic ammoniac. It was then collected and washed; and, while yet moist, boiled with caustic lye. The lixivium was then again separated by filtration, combined with muriatic acid to super-saturation, and afterwards precipitated by carbonated alkali. Only a small portion of earth fell down, which, upon trial, proved to be *siliceous*, and weighed 4 grains, after it had been exposed to a red-heat. The liquor remaining, after the precipitation of the iron, was mixed with carbonat of pot-ash; but no further precipitation nor turbidness ensued.

g) The *oxyd of iron*, that was again collected after the boiling with muriatic acid (f), was put into melted wax, in a small crucible, and heated to redness; after this last had been burned off, it obeyed the magnet, and amounted to 25 grains.

h) Upon the above 181 grains of earth (d) I poured dilute sulphuric acid; in which it dissolved with effervescence. When the solution had been reduced within a smaller compass by evaporation, it deposited minute spicular crystals, consisting of  $1\frac{1}{2}$  grain of selenite, the pure *calcareous earth* of which is to be estimated at  $\frac{2}{3}$  grain.

i) The solution, on further evaporation, yielded pure sulphat of magnesia; which, being re-dissolved, and precipitated at the temperature of boiling, by carbonat of pot-ash, deposited a very pure and loose *magnesian earth*, whose weight, after ignition for an hour, amounted to 74 grains.

It follows, from these operations, that the constituent parts of the Olivin from Unkel are, in the *hundred*,

Ignited



|                                  |    |                 |   |       |       |
|----------------------------------|----|-----------------|---|-------|-------|
| Ignited <i>Silex</i> . . .       | b) | $24\frac{1}{2}$ | } | : . . | 48    |
|                                  | e) | $21\frac{1}{2}$ |   |       |       |
|                                  | f) | 2               |   |       |       |
| <i>Magnesia</i> . . .            | i) | . . . . .       |   |       | 37    |
| <i>Lime</i> . . .                | b) | . . . . .       |   |       | 0,25  |
| Ignited <i>Oxyd of Iron</i> . g) |    | . . . . .       |   |       | 12,50 |
|                                  |    |                 |   |       | <hr/> |
|                                  |    |                 |   |       | 97,75 |
| Loss .                           |    |                 |   |       | 2,25  |
|                                  |    |                 |   |       | <hr/> |
|                                  |    |                 |   |       | 100   |

## B.

With the view of confirming these results, I undertook another decomposition of the same *Olivin from Unkel*. In this instance I treated it immediately with sulphuric acid, in the same manner as I did with the chrysolite, without previous ignition, in conjunction with alkali.

a) I put *two hundred* grains of most finely pulverized olivin in a retort, pouring upon them *ten* drachms of sulphuric acid, together with a sufficient quantity of water; and again distilled the liquid over to dryness. Upon this I softened the remaining grey-white mass with hot water, and boiled afresh the undissolved earth, separated from the fluid, with 2 drachms of sulphuric acid, and sufficient water. The liquid, filtered off from the residue there left, was added to the first solution. What remained was mere *siliceous earth*, whose weight, after ignition, amounted exactly to 100 grains.

b) The sulphuric solution (a) left, upon evaporation, a greyish-olive-green saline mass, which I evaporated still farther in a porcelain-crucible, urging it at last to a red-heat in a stronger fire. The mass retained at first its whitish colour, but at length it assumed a pulverulent state, and turned brick-red. When triturated, drenched with hot water, and filtered, it left a red *oxyd of iron*, which, after being treated with wax and ignited, weighed 24 grains.

c) After the clear solution of (b) had been evaporated in order to crystallize, it shot wholly into sulphat of magnesia: but, when it was re-dissolved in a moderate proportion of water, some crystals of sulphated lime appeared, the quantity of which indicated one half grain of pure *calcareous earth*. These last having been separated, the remaining solution was decomposed, by means of carbonated pot-ash, in boiling heat. The *magnesian earth*, thus obtained, was pure, white, and loose. When desiccated at a somewhat raised temperature, its weight amounted to  $188\frac{1}{2}$  grains; but it was reduced to only 77 grains, by ignition for the space of an hour.

By this method of analysing, which, with regard to magnesian stones, is not only the most commodious, but also indicates the results with the greatest exactness, the constituent parts of the *Olivin from Unkel* were found to be, in the *hundred*, as follows:

|                     |   |   |   |    |   |   |   |   |       |
|---------------------|---|---|---|----|---|---|---|---|-------|
| <i>Silex</i>        | . | . | . | a) | . | . | . | . | 50    |
| <i>Oxyd of Iron</i> | . | . | . | b) | . | . | . | . | 12    |
| <i>Magnesia</i>     | . | . | . | c) | . | . | . | . | 38,50 |
| <i>Lime</i>         | . | . | . | c) | . | . | . | . | 0,25  |

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 100,75

Note.



Note. The same observation applies to the agreement of this sum with the weight of the substance employed, and the slight excess, as has been already mentioned, at the end of the second analysis of chrysolite.

## SECOND SECTION.

### *Analysis of the Olivin from Karlsberg.*

THE Olivin from the Basalt of *Unkel*, employed in the foregoing examination, was, as has been mentioned, in its fresh and unimpaired state: but as most olivins shew more or less evident marks of decay, it still remained to enquire, whether, in those species of olivin that are more disposed to decay, any difference existed in their constituent parts. For this investigation I chose the *olivin* from the Basalts of the *Karlsberg*, near *Cassel*, in *Hessia*. I comminuted it coarsely, and washed off with water the yellow iron-ochre that invested its surface and its chinks. It then consisted, for the most part, of smaller grains of a faint greenish-yellow colour, but in part also of larger grains, whose colour was a somewhat fresher leek-green. In these latter I observed black-grey particles, of a metallic lustre, imbedded in, or concreted with, their substance. When I had strongly ignited some of these upon charcoal, I found that the green stony matter of the olivin had thereby become grey, dull, and opaque; while the disseminated black-grey particles had suffered no change. This shewed, that they were not minute crystals of horn-blende, but iron, and especially of the nature of the specular, or grey iron-ore, because they were not attracted by the magnet.

a) Up-

a) Upon *three hundred* grains of this olivin, finely pulverized, I poured 4 ounces of strong sulphuric acid, together with 2 ounces of water, and again distilled from it the fluid, which emitted a slight smell resembling sulphureous acid, until the residue became a dry mass. The *siliceous earth*, remaining after this mass had been boiled with water, was a second time boiled with half an ounce of sulphuric acid, and sufficient water. After this it was collected and ignited. It weighed 156 grains.

b) In order to learn whether *aluminous earth* was one of the extracted constituent parts, I took the third part of the whole of the sulphuric solution, and precipitated, by carbonated pot-ash, at the degree of ebullition, all that it held in solution. The fresh precipitate had a dirty, bluish colour; and I put it into caustic lixivium, as soon as it wasedulcorated, digesting it with the lye for some time. The mixture was next diluted with more water; the lye, separated from it by filtering, was saturated with mariatic acid; and, after a slight super-saturation, again combined with alkali. But this produced neither a precipitate nor muddiness.

c) Being thus convinced of the total absence of aluminous earth, I evaporated the remaining two-thirds of the sulphuric solution (*b*) to a dry saline mass, which I exposed to a strong red-heat in a crucible, for the purpose of decomposing the sulphat of iron which it contained. I then re-dissolved the ignited mass in water, and separated the red *oxyd of iron* by filtration; which, by ignition with wax, was rendered attractible by the magnet, and weighed, in that condition,  $21\frac{1}{2}$  grains.

d) The solution, freed from the oxyd (*c*), crystallized by degrees into sulphat of magnesia. When this had again been dissolved in a small quantity of water, light, delicate, need-



needled crystals of selenite were left, the quantity of which hardly amounted to  $\frac{1}{4}$  of one grain, which indicates  $\frac{1}{2}$  grain of pure *calcareous earth*. To the dissolved sulphat of magnesia, carbonat of pot-ash was added in a boiling heat; and thus its *magnesian earth* was precipitated, amounting, after ignition, to  $75\frac{1}{2}$  grains.

Whence the constituent parts of the *Hessian* olivin, and their reciprocal proportions in the ignited state, consist, in the *hundred*, of

|                               |              |        |
|-------------------------------|--------------|--------|
| <i>Silex</i> . . . . .        | a) . . . . . | 52     |
| <i>Magnesia</i> . . . . .     | d) . . . . . | 37,75  |
| <i>Oxyd of Iron</i> . . . . . | c) . . . . . | 10,75  |
| <i>Lime</i> . . . . .         | d) . . . . . | 0,12   |
|                               |              | <hr/>  |
|                               |              | 100,62 |

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From these results, it is plain that the olivin and chrysolite are very nearly related to each other; and, as the constituent parts of each other are so much the same, and their respective proportions not too dissimilar, it seems to me proper that these two stones should no longer be divided into two different species; but that the difference, deduced from their external characters, can only justify the subdividing them into two *varieties* of *one species*. Moreover, since no greater difference appears to take place between them, than, perhaps, that by which the basaltic horn-blende is distinguished from the common, it follows, that the olivin might be entitled to claim its former denomination of *basaltic chrysolite*.

According to the habitudes of the chrysolite and olivin in the heat of the porcelain-furnace, (mentioned in the first

first Essay, n. 25, and 61-64), the former returned from the fire unaltered in form ; but the second appeared in concreted grains, which were cemented together by the heat with more or less force of adhesion. From this circumstance I was induced to repeat the experiment with the chrysolite ; with this difference, however, that I broke it into pieces of the size of the grains of olivin, before I inclosed it in the charcoal. After those pieces had undergone the action of the fire, I found them, like ignited olivin, of an iron-black colour, opaque, thinly glazed, and conglutinated. Yet both the glazing and concretion were somewhat less in degree than what took place in the *Hessian* and *Greenland* olivins.

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## IX.

## CHEMICAL EXAMINATION

OF VARIOUS

*SILVER-ORES\**,

AT the time when Philosophical Chemistry was yet in its infancy, and when it was not known how to decompose natural bodies otherwise than by fire, with very few exceptions, the knowledge of the constituent parts of the bodies, belonging to the mineral kingdom, could not but be imperfect. Chemists were satisfied with the products obtained in the dry way, as it is called, and either paid no attention at all to the other substances contained in these bodies, or, confiding in groundless hypotheses, have fancied certain constituent parts, of which nothing could be discovered by the light kindled by Philosophical Chemistry, the basis of which is real facts.

Only, while this latter was advancing in its progress, the learned began to perceive, and seriously to attend to this great deficiency of knowledge respecting the fossil kingdom, as well as to the tottering foundation of the mineralo-

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\* Read in the Royal Acad. of Scienc. at Berlin.—See the *Collect. of Germ. Treatises* of that Acad. Berlin, 1793 and 1794.

gical systems thereon established. Accordingly, this part of Natural Philosophy was enabled, by the laudable exertions of *Schwab*, *Brand*, *Cronstädt*, *Wallerius*, *Marggraf*, *Scheele*, *Bergmann*, and several chemists now living, to rise from obscurity; and chemical mineralogy has now obtained the place, which is due to it among her sister sciences.

Yet, all that has hitherto been done in this science, is nothing more than a splendid beginning. Our acquaintance with the constituent parts of fossils is still confined within narrow limits. Not only are we still ignorant of the composition of a multitude of fossils; but, even with respect to those, with which we appear to be already acquainted, further confirmation is required: for nothing is more detrimental to the progress of a science, than to adopt errors as undoubted and long-established truths; to transfer them from one system, and from one elementary treatise, into another, and to multiply them by conclusions which must be as groundless as the premises, from which they are inferred, are false.

If, therefore, a systematical mineralogy, arranged according to the chemical constituent parts, (which, as yet, has hardly been established), is to be supported by a more solid foundation, and brought nearer to perfection, it is necessary that a long series of successive analytical experiments should be made. But since, for this purpose, a sound chemical knowledge, accompanied by patience, leisure, accuracy in management and observation, as well as a frequent sacrifice of scarce and costly fossils, are required; and since those circumstances do not usually coincide, this branch of natural science cannot hope for a speedy and plentiful harvest. It must still, therefore, as hitherto, only look for detached and occasional improvements.

Among



Among the numerous productions of the fossil kingdom, of which an exact chemical knowledge is yet wanting, the *genus of the silver-ores* seemed to me to require, in a high degree, a re-examination and amendment. For this reason I have subjected its chief species to analytical treatment; the results of which are communicated in the following sections.

## FIRST SECTION.

*Native Hornsilver, or Corneous Silver-ore. (Hornerz).*

(*Vitriolico-muriated Silver-ore*, by Kirwan.)

THE *Corneous* is remarkable among the rarer *ores of silver*, not only from its richness, but also from the substance by which nature has mineralized that noble metal.

The name *Hornerz* appears to be of a later date than our knowledge of that ore, since several writers on metallurgy, of the 16th century, have already mentioned it with the appellation of *Glaferz*; for it is obvious, from the descriptions which those authors have given of it, that they did not mean our modern *Glaferz*, namely, the sulphurated silver-ore. *Matthesius*\*, noticing several of its varieties, calls them *white, grey, yellow, green glaferz*; and says, “it is transparent like horn in a lanthorn, and fuses in the flame of a candle.”—*Fabricius*† mentions a liver-coloured silver-ore, “which in lumps, viewed against the light, is obscurely

\* *Matthesius* Sarept. 1585. Norimb.

† *Fabricius* de rebus metall. Zürich, 1566.

*transparent like horn, and in small parts is entirely transparent like ice.*"—From this it may reasonably be conjectured, that the *glaserz* of the ancients has, in later times, been erroneously confounded with our modern one, as this denomination is, indeed, more suiting the *hornerz*, or corneous silver-ore, than silver, mineralized by sulphur; and, on the other hand, no reason can be found for giving that name to the latter.

During the 16th century, in which the Saxon and Bohemian mines yielded vast treasures, the revenues arising from this silver-ore often amounted to several hundred marks (8 ounces each): but, in the progress of time, it became scarcer and less known, until the celebrated Saxon master of the mines, Mr. *Pabst of Obain*, discovered it, as it were, anew, and gave it the name *Hornerz*, because resembling the factitious *horn-silver* (muriat of silver.)

It occurred formerly at *Joachimsthal*, *Annaberg*, *Schnaeberg*, *Freiberg*, and in greatest quantities at *Johann-Georgenstadt*. At present, it is also found in some mines of the *Altaic mountains* in Siberia; and, according to *Sage*, likewise in the province of *Guamanga* in *Peru*, together with the native silver.

With respect to external form, I have met with the following varieties of the corneous silver-ore.

1) *Massive (Derbe)*. As such it has been worked, in the times of its abundance, in the above-mentioned Bohemian and Saxon mines, copiously, and sometimes in pieces of upwards of an hundred marks in weight. There may yet be seen, in the electoral-mineral cabinet, at *Dresden*, a piece of that kind, cut in a cubical form, weighing several pounds; and also a smaller one,



one, which has some impreffions of stamps. Both these ores are probably remnants of that century, which have been fortunately faved. The colour of this corneous-ore is a dirty brown, though its proper hue seems to be the pearl-grey, and the brown tinge to arise from the interspersed iron-ochre. It is soft; and may, like wax, be cut with the knife into thin chips; is possessed of a waxen gloss, and transparent on the edges and thin places.

2) In *lamellar pieces* (*schaalig*), incumbent on meager quartz, in the form of a crust; from the *Schlangenberge*.

3) In still thinner layers, in part only incrusting, (*angeflogen*, or lying superficially), at times accompanied by native gold, or also by *lead-spar*, or spathose lead-ore, from the same place.

4) *Crystallized* in minute regular cubes, of a pearl-grey colour; from *Johann-Georgenstadt*.

5) In fine *scales*, or *flakes*, of a whitish colour. In this manner the corneous silver-ore, even now, sometimes occurs at *Johann-Georgenstadt*, upon brown iron-ochre (*Eisen bräune*).

6) In an *earthy* form, mingled with argil. This is the genuine *butter-milch silver* (*argillo-muriated silver-ore*) of the former mineralogists, and which *Veltheim*\* has described. The specimen which I have seen was dug up in the year 1617, on the old St. George mountain, at *Andreasberg*, and is now preserved at Berlin, in the royal department of the

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\* *Crell's* German edition of *Kirwan's Mineralogy*. Berlin, 1765, page 281, seqq. in the notes.

mines. It consists of an *artificial*, kidney-formed nodule of calcareous spar, the cavity of which is filled with this *butter-milch silver*, in the form of a desiccated earth, externally of a slate-blue, but of a brownish white on the recent fracture; with which ore, likewise, the outer sides of the specimen are for the most part coated.

7) In grey lime-stone, but *imperceptible* to the eye; from *Annaberg*, in Lower Austria. This last is the fossil mentioned by *Justi*\*, under the name of *alkaline silver-ore*.

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\*

The following are the principal chemical researches that have been made into the corneous silver-ore, as well as its essential ingredients, and are communicated to the scientific public.

1) That of *Lommer*†, master of the mines in Saxony, who has also given the best information respecting the history and external properties of this mineral. This author estimates the argentine portion of this ore, when in pure state, at 28 *per cent.*; but the violet-ore of this kind he supposes to contain also a portion of alkalized sulphur.

2) *Woulfe*‡ is of opinion, that he has discovered, in the corneous silver-ore, besides the muriatic acid, the sulphuric, as a mineralizing medium. It is upon the authority of this statement of *Woulfe* that *Kirwan*, *Bergmann*, and other *mineralogists*, assert, that the silver is mineralized in the cor-

\* *Justi*, *Chemische Schriften*. I. Th.

† *Abhandl. vom. Hornerz, von Lommer*. Leipzig, 1776.

‡ *Experiments on the mixture of some minerals*.



neous-ore by the sulphuric as well as by the muriatic acid.

3. Sage\*, of Paris, has examined the corneous silver-ore from Peru; and states the *maximum* contained of silver, in the *hundred*, to be from 70 to 74. He adds, that the metal is mineralized by muriatic acid; and, besides, combined with a peculiar fattish matter.

4) Laxmann†, of Petersburg, on the contrary, maintains, that no muriatic acid is contained either in the Siberian or Saxon corneous silver-ore; and that in it the metal is mineralized by sulphur, in the same manner as in the glaserz, viz. the vitreous or sulphurated silver-ore.

On considering this discordance among the learned, respecting the nature of the substance which mineralizes the silver in the corneous-ore, I think that it will not be superfluous if, to the enquiries of these chemists, I add the experiments which I had the opportunity of making with several varieties of this silver-ore.

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A.

The above-mentioned *massive corneous silver-ore*, from the larger specimen in the Electoral collection at Dresden, was the principal subject of my analysis, a sufficient quantity of it having been given me for that purpose with the greatest liberality.

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\* Analyse Chim. et. concord. des trois regnes. Paris, 1786.

† Nov. Comment. Acad. Scient. Petrop. 1774.

) If the artificial horn-silver (muriat of silver), be melted by itself on the spoon before the blow-pipe, it soon and readily fuses into a globule; and, when combined with mineral alkali, the silver is immediately reduced. But the native corneous silver-ore does not melt so easily; it rather runs into the consistence of pap, and at the same time separates metallic grains transude. Its reduction, by means of soda, is somewhat more difficult than that of the artificial horn-silver, and the reason of this difference depends on the portion of iron contained in this ore.

b) Upon *two hundred* grains of the corneous silver-ore I poured three times their weight of pure nitric acid; but no action took place, either in the cold or in the heat of boiling; only a subtle brown-red iron-ochre was separated, which, being washed off from the remaining ore, and dried, amounted to 4 grains. Caustic ammoniac, added to the nitric acid employed, precipitated 5 grains more of iron. When it was afterwards mixed with muriatic acid, only a pale milky colour was produced, but no real corneous silver-ore deposited. It followed from this, that neither any free native silver, nor any portion of it mineralized by sulphur, had been contained in that ore. The horn-silver, after treatment with nitric acid, was reduced by twice its weight of salt of tartar, and yielded 133 grains of reguline silver.

c) 1st. For the purpose of finding out, more accurately, its constituent parts, I mixed 200 grains with 600 grains of the purest alkali prepared from tartar, and brought the mixture into the state of fusion in a glass retort, applying the necessary degree of heat. After refrigeration, I broke off the upper half of the retort, softened the fused mass, which was of a light-brown colour, with hot distilled water, filtered the whole, and edulcorated the residue.



2dly. This residue was then dissolved in nitric acid. The solution acquired a brown tinge, and the scum floating upon the liquor assumed the colour of bricks. When the argenteous parts were completely dissolved, there remained  $8\frac{1}{2}$  grains of a brown-red powder, which imparted a golden yellow colour to the aqua regia, with which it was digested, and left a white residue behind. This last consisted of horn-silver, mingled with a slight portion of the *gangue*, or *matrix* of the ore, and afforded, on reduction, 2 grains more of *silver*. Caustic ammoniac precipitated from the yellow solution 7 grains of *oxyded iron*.

3dly. The nitric solution of the silver was precipitated by common salt; and the muriat of silver thus obtained weighed, after reduction by means of soda,  $134\frac{1}{2}$  grains of reguline silver.

4thly. The fluid, left after the separation of the horn-silver, had a pale-yellow colour, owing to a *portion of iron*; which, precipitated by pure ammoniac, weighed 5 grains.

5thly After this, I proceeded to examine the saline mass, dissolved in distilled water, and separated from the silver, after the corneous-ore had been fused with pure alkali (*i*). On saturating this mass with distilled vinegar, the solution was rendered turbid, and a loose white earth deposited, which, collected and dried, amounted to  $3\frac{1}{2}$  grains of *argillaceous earth*.

6thly. The argil being separated, the solution was reduced to a dry salt by evaporation, and the alcohol, affused upon it, took up the acetite of pot-ash. The neutral salt, which was left behind by this process, and which consisted of the mineralizing muriatic acid and the alkali employed, I dis-

solved in water, and obtained from it, by repeated evaporation and crystallization,  $117\frac{1}{2}$  grains of *muriat of pot-ash*.

7thly. In order to learn whether and in what proportion *fulphuric acid*, which by some writers has been mentioned as one of the constituent parts of the corneous silver-ore, were really present in it, I again dissolved that salt in distilled water, and dropped into it liquid *muriat of barytes*. The mixture became turbid, exhibiting that appearance which indicates the presence of only a slight quantity of *fulphuric acid*. I continued to add the *barytes*, until no more turbidness appeared. The weight of the precipitate thus obtained was 3 grains: but, as in these three grains of *fulphated barytes* the acid cannot properly be estimated to be more than half a grain, I think this quantity is too trifling to be considered as one of the essential constituent parts of the corneous silver-ore. But if that half grain of *fulphuric acid* be estimated equal to  $1\frac{1}{2}$  grain of *fulphat of pot-ash*, and be subtracted from the above  $117\frac{1}{2}$  grain of *digestive salt*, or *muriat of pot-ash*, there will remain of the latter only 116 grains, in which the concentrated *muriatic acid* amounts to 42 grains. Therefore,

One hundred parts of this corneous-ore contain

|                               |       |
|-------------------------------|-------|
| <i>Silver</i> . . . . .       | 67,75 |
| <i>Muriatic acid</i> . . . .  | 21    |
| <i>Oxyd of iron</i> . . . .   | 6     |
| <i>Argil</i> . . . . .        | 1,75  |
| <i>Sulphuric acid</i> . . . . | 0,25  |
|                               | <hr/> |
|                               | 96,75 |



## B.

I likewise examined the *corneous silver-ore* found in the *Schlangenberg*. One hundred grains of it, mixed with 300 of soda, were fused in a small retort; and, after the saline contents of this mass had been dissolved in hot water, the remaining silver was dissolved in nitric acid. I then fully saturated with muriatic acid the aqueous alkaline solution, which contained the common or culinary salt, formed by the muriatic acid of that ore, and put it to the test with muriat of barytes. The portion of sulphat of barytes, thus generated, was as insignificant as that from the Saxon *corneous-ore*; so that also, in this case, the sulphuric acid may be considered only as an accidental constituent part.

To the nitric solution of the silver I added common salt; and thus I produced again the muriat of silver, which weighed  $91\frac{1}{2}$  grains, and afforded 68 grains of *silver*, reduced to the reguline state. What was wanting to make up the first hundred grains of the *corneous-ore*, consisted of ferruginous ochre and quartzose matrix.

Hence it is obvious, that the *Siberian corneous silver-ore* here examined, almost perfectly agrees with the preceding *Saxon* one in its exterior characters, as well as in the constituent parts.

## C.

The experiments made with the *argillo-muriated silver-ore* (*butter-milch silver*), described before (page 113), are the following:

a) Ignited by itself upon charcoal before the blow-pipe, it feebly conglutinated together, at the same time that mi-

nute globules of metallic silver were oozing through the mass. When fused with glass of borax, it dissolved into a clear, light-green, vitreous globule, and yielded a button of pure fine silver.

b) Upon 35 grains of that ore I poured nitric acid, and made it boil. Neither effervescence nor red vapours appeared; as, upon the whole, the acid seemed to attack it but weakly. The residuum assumed the form of a precipitate, resembling a cheesy coagulum. When the acid, then tinged of a faint blue, was separated through a filter, it admitted of combination with common salt, without being rendered turbid, or yielding any precipitate. By the addition of carbonate of ammoniac to excess, argillaceous earth was thrown down, and the liquor appeared of a rather deep blue. But, after it had been super-saturated with sulphuric acid, and iron immersed into it, it deposited a thin coppery crust.

The dried residue weighed 30 grains. It was extracted by repeatedly pouring upon it caustic, or pure ammoniac, agitating it frequently. Nitric acid being added to a few drops of it, some horn-silver immediately precipitated. The whole of this solution, when evaporated by a gentle heat, dried up to crystalline flexible membranes of a pearl-grey, which tarnished into blue by exposure to air; and, when gently melted in a small silver-cup, ran into a waxy substance. The weight of this fused muriat of silver amounted to  $10\frac{1}{2}$  grains.

When the argil, that was left behind after the extraction of the horn-silver by ammoniac, was melted with soda, it still afforded a bead of silver of  $\frac{1}{4}$  of a grain. As this is equal to one grain of muriat of silver, the above 36 grains of this  
fossil



fossil contained  $11\frac{1}{2}$  grains of muriated, or  $8\frac{5}{8}$  of metallic silver, and  $2\frac{7}{8}$  grains of concentrated muriatic acid.

Hence one hundred parts of the argillo-muriated silver ore contain,

|                                                |       |
|------------------------------------------------|-------|
| Silver . . . . .                               | 24,64 |
| Muriatic acid . . . . .                        | 8,28  |
| Argil, with a slight trace of copper . . . . . | 67,08 |

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It is owing to the argil contained in this ore that it does not assume the same appearance when heated on charcoal as the common horn-silver, but that the metal transudes in the reguline state in small globules; for as that earth deprives the muriated silver of its acid when heated, the silver is enabled to assume the metallic state. And it is on this account that the same phenomenon took place when I mingled artificial horn-silver with argillaceous earth, and subjected it to ignition upon a piece of charcoal, with the assistance of the blow-pipe.

### D.

With the view of investigating the nature of the silver-ore, called *alkaline* by *Justi*, I dissolved one ounce of it in pure nitric acid, and mixed the filtered solution with muriatic acid. It, indeed, turned somewhat opaline; but no muriat of silver was separated by this process, nor was there any reguline silver precipitated upon immersing into it a small lamina of copper. Finding, therefore, that the portion of silver contained in the lime-stone could not be discovered in the nitric solution, I searched for it in the brown muddy residue of the filtered solution. This emit-

emitted an empyreumatic smell on being gently ignited, weighed afterwards 2 grains, and yielded with pure alkali a bead of fine silver. Hence it is probable, that in this fossil the silver is combined with muriatic acid; and, reckoning upon this result, the quantity of muriated silver which it seems to contain, may be estimated at from *one and a half* to *two* ounces in hundred pounds. *Justi* boasted of a method of extracting the silver from that mineral, known to himself alone; as, when treated by any of the usual processes, this metal could never be procured from it.

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As silver, notwithstanding its great affinity with muriatic acid, enters into no combination with it while in the perfect reguline state; and since that metal, as far as we know, is never found in the bowels of the earth in an oxyded state, it is difficult to ascertain the operation of nature in producing the corneous-ore. *Bergmann*\* was of opinion, that *Woulfe* had solved that doubt by asserting, that in the above-mentioned ore he had traced the sulphuric acid, besides the muriatic: for silver unites readily with sulphur; and, since sulphurated silver not unfrequently undergoes a decomposition, more especially when, as in this case may be conjectured from the presence of ferruginous ochre, some pyrites disposed to disintegration intervenes, the sulphur passes over into the state of a free acid, and forms sulphat of silver. If now muriatic acid interferes, it will, by virtue of its greater affinity to silver, decompose the sulphat, and instead of it form corneous-ore.

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\* *Torb. Bergmann* on the generation of natural corneous, or muriated metals. *Grell's Chemische Annalen*, 1784. Number 4, page 377.



Of that corneous silver-ore which is found in regular cubic crystals, *Bergmann* had already conjectured that it might be considered as pure, and free from all sulphuric acid. He also wished to convert this conjecture of his into an established truth, by duly examining that fossil; *for*, as he very justly says, *it is better to sacrifice such a specimen, scarce as it yet is, to investigation, rather than to deprive the sciences of a means of enlarging our knowledge by preserving it.*

The wish of the immortal *Bergmann* is in some degree accomplished, and his conjecture, for the most part, confirmed by the present enquiry; with the unimportant difference, however, that, instead of crystallized corneous-ore, I have employed a specimen of that which occurs in lumps, or *massive*.

In order to comprehend how nature can generate the corneous silver-ore, without the interposition of sulphur or sulphuric acid, we may receive some light from the following intelligence, taken from a letter of *Proust*, in *Rozier's Journal de Physique*. It is there stated, that the coined silver of the Spanish ship *San Pedro d'Alcantara*, that was wrecked on the coast of Portugal, became coated with a blackish crust of  $\frac{1}{48}$  of an inch thickness, during the short time before it was recovered from the sea. This crust broke off in scales, and was a true muriat of silver. Moreover, *Pallas*\* relates, that he has found on the *Jaik*, in Siberia, several old Tartarian silver coins, which in that tract of saline land were converted into true muriat of silver, some throughout their whole mass, and others on the surface only.

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\* *Nordische Beytraege*, III. Vol.

From this knowledge of the constituent parts of the corneous-ore, art is enabled to imitate nature pretty nearly. If muriat of silver be made to fuse uniformly at a moderate heat, an artificial corneous-ore is produced, which may be made more similar to the natural one by adding, before the fusion, a proportional quantity of iron-ochre. And if muriated silver be dissolved in caustic ammoniac, and the fluid evaporated in a gentle warmth, the horn-silver remains in small glittering scales, resembling those with which the native corneous-ore is found in part covered. But, if this solution be left to spontaneous exhalation in the air, the horn-silver will sometimes shoot into solid regular crystals, of the same appearance with the cubic crystals of the corneous-ore.

## SECOND SECTION.

### *Red Silver-ore (Rothgültigerz).*

THE principal character by which this beautiful genus of silver-ores is externally distinguished from others, consists in a peculiar red colour, on account of which it is subdivided into two species, the *light*, and the *deep-red* silver-ore. The colour of the first varies from a bright ruby to a garnet red; that of the second inclines more or less to a steel-grey, but the characteristic crimson tint is soon made to appear by scraping or rubbing the ore. The deep-red silver-ore is usually opaque; the light-red, on the contrary, is in various degrees transparent.

With respect to external form, the red silver-ore is found *massive*, *disseminated*, *investing* or *superficial*, *dendritic*; and at times regularly crystallized. Its crystals usually possess the form of hexahedral columns, without any pointed

ter-



termination, or ending in trihedral or hexahedral pyramids. The light-red ore also occurs in six-sided pyramids.

The denomination of *Rothgültig*, or *Rothe gültiges Erz*, given by the older German miners to this genus of silver-ores, was intended to signify that it contained a portion of that noble metal, and thus to distinguish it from other ores, which resemble it in form and colour; but, with respect to their argenteous contents, are *deaf* (*ungültig*), or of no value; instances of which are afforded by the native red sulphuret of arsenic, red-blende, and garnet. In process of time, this appellation has degenerated into *Rothgülden*, by which the unexperienced might be misled to suspect in this ore some portion of gold.

Concerning its constituent parts, it is the common opinion and doctrine, that the silver is mineralized in it by *arsenic*, as well as by sulphur. These three, *silver*, *sulphur*, and *arsenic*, are in all elementary books of mineralogy, and by all authors, stated as the constituent parts of this ore, to which some add only a portion of iron. Among those writers which, in *chemical mineralogy*, are reckoned classical, *Henckel* seems to be the first who mentions arsenic as one of the chief constituent parts of the red silver-ore, when he says, "*The high-red ore, besides silver, consists merely of arsenic; the deep-red contains sulphur also.*" After him, *Wallerius* introduces it by the name "*Argentum arsenico et sulphure mineralisatum.*" *Cronstedt* adopts this statement, adding only some ferruginous ingredient. *Bergmann*, likewise, is of the same opinion, in his *Sciagraphia*\*, calling it "*Argentum cum arsenico sulphure*

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\* Torb. Bergmann, *Sciagraphia regni mineralis*. Lips. et Dresd. 1782, page 108.

*mineralisatum*:" and, in his dissertation de *Arsenico*\*, he says, "*Arsenicum cum argento sulphurato mineram argenti rubram conficit*:"—and at the same time he states their proportion to be, of *silver* 60, of *arsenic* 25, and of *sulphur* 13†. It was on the authority of these eminently learned men that all the other writers have received the above-mentioned component principles of this ore as unquestionable facts, and have transferred them into their works.

Yet, upon the whole, arsenic is not so general a mineralizer as has been hitherto supposed. Hence all the hypotheses grounded on its pretended presence, and according to which arsenic was considered as a principle necessary to the generation or maturation of metals, especially silver, can no longer subsist. This supposition, which has never before been questioned, that most genera of silver-ores contain arsenic, has occasioned the *prize question* of the *Royal Academy of Sciences at Berlin*, 1773, "*To what purposes does Nature employ the arsenic contained in metallic ores? Can it be proved, by experience, that it effectually serves to bring the metals to maturity? And if so, in what manner, and how far is this effected?*"—However truly Mr. Monnet, whose paper has been honoured with the prize, has demonstrated that arsenic has no essential share in the generation of metals, he might as well have deduced his demonstration in the shortest and most solid way, *a priori* from the non-existence of arsenic in the red and white silver-ores, and in the grey copper-ore (*Fablerz*) abounding in silver—(for these the above Academy seems principally to have had in view on making their question)—had he convinced himself of the falsehood of the premises by a previous enquiry duly instituted.

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\* Ejus'd. Opuscul. Phys. et Cham. Vol. II. page 298.

† Loc. cit. page 303.



It is probable the red-arsenic, which externally resembles the deep-red silver-ore, and, according to *Henckel's* testimony, used to be called *unripe red silver-ore*, has first suggested the idea of the presence of arsenic in those ores of silver.

After this digression, I now proceed to the chemical analysis itself. This, however, was particularly performed with the light-red silver-ore, of which I had an opportunity of selecting, for my repeated experiments, a sufficient number of fragments, pure and free from extraneous matter, from the mines of the *Upper-harz*, and those of *Saxony*.

---

A.

a) Upon *five hundred* grains of bright, crystalline, red silver-ore, from the pit *Catharina Neufang*, at *Andreasberg*, most finely pulverized, I poured six times their quantity of a mixture of equal parts of nitric acid of 1,350 specif. grav. and distilled water. The phial was kept for several hours in a low digesting heat, so that the agency of the acid could be but moderate. I then diluted the solution with water; caused it to boil; and, after the residuum had subsided to the bottom, I decanted the clear solution. Upon the remaining pulverulent ore, a quantity of nitric acid and water, equal to the preceding, was again affused; and, in the same manner, proceeded with as at first. The ore appeared now to have been effectually decomposed; and for this reason the solutions, together with the residuum, were put on the filter, and the latter properly washed.

b) The filtered nitric solution had no colour at all, having been very much diluted by the water by which the residue  
had

had beenedulcorated. I subjected it to evaporation to one eighth part, and found the bottom of the evaporating glass-vessel, after cooling, covered with copious, finely-grained, replendent, and heavy crystals of a grey-white. To ascertain their nature, I procured, by a separate process, a quantity of a solution of the same red silver-ore, sufficient for this enquiry, and found that they were *fulphat of silver*. Being assured of this, I dissolved that fulphat by a proportionate quantity of water, assisted by heat, added it again to the nitric solution, and combined this last with muriatic acid, as long as any muriat of silver would precipitate; which, when collected,edulcorated, and dried, was found to weigh  $391\frac{1}{2}$  grains.

c) The fluid, from which the horn-silver had been thus separated, was then reduced to a smaller bulk, by distillation from a retort. This concentrated fluid became turbid, and left another grain of muriated silver on the filter. At this time it contained no other foreign substance, except a considerable portion of sulphuric acid.

d) What remained undissolved by the nitric acid, consisted of an ash-grey, pretty loose, or flocculent powder, of 202 grains in weight. When this had been gently digested for half an hour, with a mixture of 5 parts of muriatic acid, mixed with 1 part of the nitric, and then diluted with half its quantity of water, there remained, after filtering, carefuledulcoration, and drying, 65 grains; which were the sulphureous contents of the ore. When this residue had been gently heated, the sulphur deflagrated, leaving  $6\frac{1}{2}$  grains of muriated silver behind. This *sulphur*, therefore, consisted of  $58\frac{1}{2}$  grains.

e) After the filtered solution had been evaporated in part, it was poured into a large quantity of water. By this  
ma-



management, a white precipitate immediately ensued, which being separated by the filter,edulcorated, and dried, and lastly heated in a porcelain cup, gave 133 grains in weight. But I could not find the least trace of arsenic in it, though I had subjected it to all the trials deemed proper for discovering its presence. On the contrary, it was manifest, that this precipitate wholly consisted of *oxyd of antimony*, quite of the same nature with that which is produced when muriatic solutions of antimony are precipitated by water. On exposing it to heat, a small portion of moisture still evaporated, attended with a muriatic smell, which was hardly perceptible. When again put on a test, and mingled with a third part of charcoal dust, the coaly powder was slowly consumed, by burning, without any arsenical smell, and left behind it the metallic oxyd, possessed of a grey colour, and partly blended, partly covered with a quantity of fine, grey-white, shining, acicular crystals, or the flowers of antimony, as they are called. But when it was fused in a covered crucible with tartar and powdered charcoal, it was completely revived into *reguline antimony*, which being blown off with the bellows, a *bead of silver* was left, weighing half a grain.

f) The liquor also, from which the antimonial oxyd was separated, contained free sulphuric acid. On this account I put it into a retort, together with the nitric acid, from which the silver had been precipitated in the state of horn-silver, by means of muriatic acid, and continued the distillation until, at this temperature, nothing more would pass over; but, on raising the heat, thick white vapours had begun to rise. The fluid left behind in the retort was found, upon trial, to be concentrated *sulphuric acid*. Upon diluting this last with water, and subsequent affusion of muriated barytes, the sulphat of barytes from thence produced,

duced, amounted, afteredulcoration and desiccation, to 194 grains.

Consequently, the constituent parts discovered by these researches, are, *silver, antimony, sulphur, and sulphuric acid*. It remained yet to investigate, what are the proportions and the manner of combination of these principles, which constitute the red silver-ore.

*First*, concerning the quantity of silver contained in this ore here examined, the muriat of silver (*b*) together with those portions that were left behind on the deflagration of the sulphur (*d*), and the concentration of the fluid from which the former had been separated (*e*), amounted, in the whole, to 399 grains. These being reduced, (including the one half grain obtained on driving off the antimony), yielded 300 grains of pure silver. This statement also perfectly agreed with the result of another experiment, which, by way of collateral proof, I performed in the dry way: for having, with this view, divided one *docimaſtic centner* of that ore into two parts, and carefully refined each of them on the cupel, inclosed in four times their weight of hammered lead, I recovered in each cupel a bead of fine silver of 30 pounds weight.

I endeavoured to ascertain, by the following counter-experiments, the metallic portion of the *oxyd of antimony*; which, after deducting, by guess, one grain for the half grain of silver which was contained in the ore, amounted to 132 grains. Upon *one hundred* grains of pure reguline antimony I poured four parts of muriatic acid; and, when warmed, I continued dropping nitric acid into this fluid, until all the metal was dissolved. After the solution had been concentrated by gentle evaporation, I added water to precipitate the dissolved metal. The precipitate thus obtained, after  
lix-



lixiviating the saline parts, and desiccation, weighed 130 grains. Hence the above 132 grains are equal to  $101\frac{1}{2}$  grains of metallic antimony.

With regard to the *sulphuric acid*, it may be doubted, whether the acid here discovered, had really previously existed as such in the red silver-ore, forming, with the metal, sulphat of silver; or whether that acid ought not rather to be considered as a product, arising from the oxygenation of the sulphur, while the ore was dissolving in nitric acid. But even the external properties of that ore, especially its transparency, and the absence of metallic lustre, will sufficiently prove, that the latter is not the case: for, with regard to the mineralization, ores may be conveniently divided into two classes. The *first* comprehends the true ores in the strict sense; that is, those only in which the metallic portion is either in the perfect, or very nearly perfect, reguline state, and whose mineralizer is sulphur. A metallic lustre, and absolute opacity, are essential properties of sulphurated ores of this kind. To the *second* class belong those ores, the metallic part of which is acidified by oxygen, either alone, or in combination with sulphur and acids. The exterior characters of the ores of this class are various. Some of them are *transparent* even to *pellucidity*; others, on the contrary, exhibit only an earthy appearance. But all these are particularly distinguished from the genuine or true ores, by the total absence of metallic splendour. Among the silver-ores, therefore, the *vitreous silver-ore* (*glaserz*), the *black silver-ore* (*sprödglass-erz*), and the *white silver-ore*, belong to the first class, or sulphurated ores; but the *red*, and the *corneous silver-ore*, belong to the second class, or ores mineralized by acid principles.

The peculiar manner in which the nitric acid exerts its dissolving power on the red silver-ore during the digestion,

affords another argument to shew, that in this ore the portion of silver does not exist in its perfect metallic state, and mineralized by sulphur; but, on the contrary, is combined with oxygen, at least for the greater part; and hence, that it there exists in a calciform state. The nitric acid acts upon it much too weakly, to oxygenate the sulphur in any considerable degree; in consequence of which, only a proportionally small quantity of nitrous gas is produced in this solution. This fact is still more confirmed by the following experiment. Some finely pulverized red silver-ore, together with a large quantity of strong muriatic acid, were subjected to digestion for some hours, at a boiling heat. The acid, separated by filtration, was examined after cooling, and was found to contain, not only silver, and antimonial particles, but also sulphuric acid. Now, as muriatic acid alone is incapable of converting sulphur into a free or uncombined acid, it follows, that the sulphuric acid must already before have existed in that ore, in the capacity of an acid. Even *Henckel*, whose great merits in chemical mineralogy are at present almost totally disregarded, has already stated it as a certain fact, that the silver may be extracted from its red-ore, by muriatic acid alone, assisted by successive digestions at the degree of boiling. It is also probable, that the sulphuric acid, present in that ore, contributes to the solubility of the metal in the muriatic acid.

The sulphuric acid, contained in the above 500 grains of the red silver-ore, produced 194 grains of sulphated barytes. Other comparative experiments proved to me that this acid amounted to  $85\frac{1}{2}$  grains of 1,850 specific gravity. But as this acid must be supposed to be combined in this ore with the silver in a concrete state, or *freed from* water, and not in the state of liquid sulphuric acid, I hope to come pretty near the mark, if, till a more accurate computation can be made,



made, I allow 40 grains for the sulphuric acid of that degree of concentration.

In order to ascertain whether any volatile parts, and of what kind, were discharged by the red silver-ore, when treated in fire with exclusion of air, *one ounce* of it, coarsely triturated, was placed in a small glass-retort, which, being connected with the pneumatic quicksilver-apparatus, I continued to heat till the ore was in fusion. However, nothing passed over into the jar filled with mercury, excepting that portion of atmospheric air, which was expelled from the retort by the heat. In the intermediate glass-balloon *volatile sulphureous acid* collected, in the form of fine drops of dew; in the neck of the retort there appeared a slight trace of sublimed yellow sulphur; but the ore in the retort did not lose so much as one entire grain of its weight.

These same experiments, made for the purpose of discovering the ingredients in the red silver-ore, I repeated with another specimen from the same mine; but, as the result of these last, excepting some unimportant deviations, agreed with the former, I am satisfied with the constituent parts resulting from the investigation of the above-mentioned 500 grains, and which are:

|                                   |       |
|-----------------------------------|-------|
| Silver . . . . .                  | 300   |
| Reguline antimony . . . . .       | 101,5 |
| Sulphur . . . . .                 | 58,5  |
| Concrete sulphuric acid . . . . . | 40    |

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500 grs.

Therefore, *one hundred parts* of this *red silver-ore*, from *Andreasberg*, contain:

K 3

Silver

|                                          |       |
|------------------------------------------|-------|
| <i>Silver</i> . . . . .                  | 60    |
| <i>Reguline antimony</i> . . . . .       | 20,3  |
| <i>Sulphur</i> . . . . .                 | 11,7  |
| <i>Concrete sulphuric acid</i> . . . . . | 8     |
|                                          | <hr/> |
|                                          | 100.  |

## B.

The second species of the red silver-ore, which I have analysed, is the *bright-red and crystalline*, from *Ghurprinz Friedrich August*, near *Freiberg*. But, as I treated these in the same manner as the preceding, I shall confine myself to the results only; according to which, *one hundred parts* of this ore contain:

|                                          |       |
|------------------------------------------|-------|
| <i>Silver</i> . . . . .                  | 62    |
| <i>Reguline antimony</i> . . . . .       | 18,5  |
| <i>Sulphur</i> . . . . .                 | 11    |
| <i>Concrete sulphuric acid</i> . . . . . | 8,5   |
|                                          | <hr/> |
|                                          | 100.  |

This *Saxon* fossil, therefore, perfectly agrees with that from the *Harz*, with regard to its constituent parts, and likewise very nearly as to their proportions. The quantity of silver also was found to be the same, when the process was performed in the dry way; since 100 pounds of this ore, properly dressed or mingled with four times its weight of lead, and subjected to cupellation, likewise afforded 62 pounds of metallic silver.



In this *Saxon* red silver-ore, as in the foregoing, there was no vestige of arsenical matter to be found, although arsenic constantly accompanies the ores dug out from that mine.

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In the preceding analytical researches, concerning the red silver-ore, I have indeed mentioned *fulphur*, and *fulphuric acid*, as two particular products; yet I do not mean to say by this, that they are two separate and really distinct constituent parts, actually existing in the ore. It is rather more probable, from the nature of the subject, to suppose, that in the undecomposed ore, both together constitute only one homogeneous ingredient part, and that the oxygen, by which the sulphuric acid was generated in this process, had before been uniformly diffused over the whole mass of the sulphur. But, if so, there is no doubt, but that the red colour of the ore, which in general is erroneously ascribed to some arsenical matter, depends on that state of sulphur in its first degree of oxygenation, which by some is rightly called *oxyd of sulphur*. On this account, the *silver*, *antimony*, *sulphur*, and *oxygen*, are, in the strict sense, the genuine constituent parts of the red silver-ore, taken in its natural state.

Lastly, I did not think it necessary to re-examine what *Bergmann* asserted, in his Essay de *Arsenico*, concerning the red silver-ore. He says—“*Minera argenti rubra egregie aquâ forti decomponitur, argentum et arsenicum suscipiente, adeo, ut tandem solum sulphur in fundo restet.*” From this it might be inferred, that *Bergmann* had employed for this experiment a specimen of the red silver-ore, which had no antimony, but really some arsenic, among its constituent

parts; otherwise, by the established principles of chemistry, the antimonial part of the ore must of course, together with the sulphur, have remained behind as a metallic oxyd, insoluble in nitric acid. In order to set this contradictory point in a proper light, I boiled five parts of strong nitric acid upon 100 grains of this red ore for some time; after which the mixture was diluted with water, and the solution filtered while yet warm. This extraction by strong nitric acid was successively repeated, until only a small portion of sulphur remained. The solution procured by the first digestion, deposited, in the cold, granular sulphat of silver; but those of the succeeding digestions yielded also some particles of antimony, which subsided in delicate, light scales, of a silvery lustre. By this experience, therefore, I learn, that reguline antimony, instead of being corroded by nitric acid into an indissoluble oxyd, makes an exception from that rule when in combination with sulphuric acid, as was here the case. And, for this reason, I found that a solution of this metal was effected, when, by way of a comparative trial with pure reguline antimony, I used a menstruum composed of strong sulphuric and nitric acids. This fact has already been mentioned by *Wenzel*\*. Upon this property of antimony, that its solubility in nitric acid is promoted by the sulphuric, is founded the rule that ought to be observed in performing processes on the red silver-ore; which is, that for the purpose of extracting its silver, weak nitric acid, and only a gentle digestion, should be employed.

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\* See his *Lehre von der Verwandtschaft der Körper*. Dresden, 1777. page 182.



## THIRD SECTION.

*Vitreous Silver-ore.* (Silberglanzerz.)

THE appellation *glaserz*, which the German miners have given to this richest sort of all silver-ores, is inconsistent with its real natural qualities, and can only have been retained from the antiquity of the term. Not only is the absolute opacity of this ore, but also its softness, and ductility, (on account of which it may be cut, hammered, and coined, as easily as lead) are absolutely incompatible with the notion of *glafs*. An instance of the last mentioned property is afforded by those medals, which were made of it under the reign King *Augustus* I. (of Poland,) and had the impression of his portrait. *Henkel*\* was therefore fully entitled to say—" *Glaserz* is meant to signify the same as " *glanzerz*, which name it probably has received at those " mines, where no other ore, constantly possessing lustre, was " to be found; and, in particular, it seems, that the miner " who gave it first that name, happened to meet with a spe- " cies of *glaserz* of variegated colours." Supported by this authority, and still more so by the nature of that ore, I shall make use of the more suitable denomination, *silberglanzerz*.

That this species of ore is a mere *sulphuret of silver*, is too well known to need farther confirmation. Only the proportion of its constituent parts, as stated by mineralogical writers, appeared to me to require correction. This, upon *Bergmann's*† authority, is generally said to be 75 parts

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\* *Henkel redivivus*. page 51.

† *Sciagr. reg. min.* § 163.

of silver, and 25 of sulphur. The portion of the silver is rated much higher by Brünich\*: namely, at 180 marks, or at ninety in the hundred. On the contrary, Sage† estimates the sulphur at 16 parts in the hundred of this ore, and consequently the silver at 84. By the following experiments it will be seen, that of these two, the opinion of Le Sage is the nearest to truth. That this more accurate statement was before known among the earlier authors in mineralogy is proved by these words of Lazarus Erker‡ “ Thus we may reckon among the silver ores of easy fusion, the most eminent of these, the glaserz, which is compact, of a lead colour, in quality nearly equal to native silver, and loses in the fire little more than one sixth part, all the rest being good pure silver, &c.”

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A.

a) One hundred grains of cubically crystallized vitreous silver-ore (from the mine *Himmelsfürst*, near *Freiberg*), previously cut into shreds, were digested, in a low heat, in eight times their weight of nitric acid, of 1,350 specif. grav. diluted with half its quantity of water. The activity of the acid proved to be but moderate, partly because, as the ore was not capable of being pulverized, on account of its softness and ductility, the shreds presented a considerably smaller surface to the acid. After the solution had

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\* Cronstedt's Mineralogie, verm. d. Brünich. 1780. page 186.

† Analyse. Chim. et concord. de trois regnes. par M. Sage. Paris, 1776. Tom. III. page 250.

‡ Erker Probierekunst. Francfort, 1598. page 3.



been accomplished, the remaining brownish-yellow sulphur, when separated, washed, and dried, weighed 13 grains; but, on being burnt on a porcelain test, it left one grain and a half of sulphated silver, which, fused with mineral alkali, gave a silver-button of one grain.

b) The colourless nitrous solution, when combined with common salt,edulcorated, and highly desiccated in a warm temperature, yielded 122 grains of horn-silver, the metallic portion of which amounted to 84 grains. By this, including the above-mentioned *one* grain, the proportion of the silver contained in 100 parts of that ore is determined at 85.

c) The fluid decanted from the muriat of silver, contained nothing but a small proportion of disengaged sulphuric acid. This, however, should not in this instance be considered as a constituent part of the ore, but was undoubtedly formed during its long digestion in nitric acid. Hence those 15 grains, which, after deducting the 85 of silver, remain to make up the 100 of the ore employed, may all be safely put into our account, as its sulphureous part.

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## B.

Next, in order to examine the truth of the preceding result, in the dry way, I took the vitreous silver-ore from *Joachimsthal*, in Bohemia. An hundred grains of it were divided into two parts, and each of them placed in a separate assaying test, well dried beforehand under the muffle. Heat was then applied, at first moderate, to drive the sulphur

phur slowly off, and only towards the end its intensity was increased to the requisite degree. The beads of silver obtained from each test, were of equal weight, and their sum amounted to  $84\frac{1}{16}$  grains.

In consequence of the approximation of this last result to that of the foregoing experiments, the constituent parts of pure, ductile, vitreous silver-ore, taken upon an average, are proved to be:

|                          |       |
|--------------------------|-------|
| <i>Silver</i> . . . . .  | 85    |
| <i>Sulphur</i> . . . . . | 15    |
|                          | <hr/> |
|                          | 100   |

#### FOURTH SECTION.

##### *Brittle Vitreous Silver-ore.*

(*Sprödes Silberglanzerz.*)

THAT silver-ore, which occurs in the Saxon mines, with the name of *spröd-glaserz*, and to which the *röschgewächs*, as it is called in Hungary, seems to belong, is distinguished, as to its external properties, from the species last mentioned, both by its darker colour, and by its brittleness, or want of ductility. *Wallerius* and others ascribe that friability to an admixture of arsenic; but without reason, since this property is owing to an antimonial ingredient.

For the subject of my present analysis, I selected the lamellated, friable, vitreous silver-ore, from the mine *Alte Hoffnung Gottes*, at *Großvoigtsberg*, near *Freiberg*, which is there found in thin tables, for the most part cellularly accumulated, of a black iron-colour, and is associated with a  
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sort of calcareous spar, crystallized in low six-sided columns, with trihedral terminations, which is met with in the clefts of a rock of *Gneiss*.

a) If ductile vitreous silver-ore be fused upon a piece of charcoal, by the assistance of the blow-pipe, its sulphur is quickly volatilized, and a button of pure silver remains. But it is otherwise with the brittle ore: for the bead left after the evaporation of the sulphur is brittle, and cannot be purified by the addition of borax. However, if a little nitrat of pot-ash is added to the red-hot bead, it will destroy the portion of baser metal which it contains, and then the borat of soda causes it to yield a pure button of silver.

b) One hundred grains of ore, previously levigated, were gently boiled in a sufficient quantity of nitric acid, diluted with an equal quantity of water. This operation was repeatedly performed, till the black colour of the powdered ore disappeared, and the insoluble portion had become of a loose texture, and had acquired a grey-yellow colour. When filtered and dried, this residue weighed 26 grains.

c) On adding a solution of common salt to the above filtered solution, which had assumed a pale-greenish colour, a copious precipitate of horn-silver ensued, which,edulcorated and dried, gave  $88\frac{1}{2}$  grains. Four parts of this afforded three of *silver*, by fusion with soda.

d) The remaining solution was next combined with sulphat of soda; but neither any turbidness, nor any indication of the presence of lead, appeared. Upon this, caustic ammoniac was affused to excess; and the grey precipitate, which then fell down, and which the volatile alkali could not again render soluble, weighed five grains. Urged by heat, it melted into a consistence, like pap, at the same time that

that a weak arsenical smell was perceived. After this precipitate had been once more dissolved in nitric acid, the addition of soda caused it to yield a whitish-yellow, alkaline sulphuret, a dirty brown, and Prussian alkali, a deep-blue precipitate, liable to the attraction of the load-stone, after ignition. Therefore, it consisted of *iron*, with a slight trace of *arsenic*.

e) The proportion of copper, indicated by a blue colour, in consequence of the addition of ammoniac, and which still remained in the solution, was but slight. For, after the solution had been saturated with sulphuric acid, polished iron immersed in it, was invested with so slight a coppery crust, that no copper to any amount could be collected.

f) Those 26 grains, which continued insoluble in the nitric acid (*b*), were digested in nitro-muriatic acid, till nothing appeared to remain but the mere *sulphur*. Its weight amounted to 13 grains; but, after deflagration, it left behind it about one grain of *quarzose matter* of the mine.

g) From this it is obvious, that 13 grains, or one half of the above 26 grains, were held in solution by the nitro-muriatic acid; and these were precipitated entirely in the form of a white powder, upon the affusion of 20 parts of water. When ignited, this precipitate assumed a yellowish colour; but there was nothing, either of arsenic, or any other volatile substance, perceivable. By combination with soda, it became reduced to pure reguline *antimony*; which, as such, admitted of being blown off without leaving any residue, in its usual form of a thick white smoke, adhering to the contiguous bodies in the form of needle-shaped flowers (*oxyd*) of antimony. Those 13 grains of oxyded antimony



mony are equivalent to ten grains of that metal in the reguline state.

One hundred grains, therefore, of this foliated, brittle, vitreous silver-ore, contain:

|                                           |       |
|-------------------------------------------|-------|
| Silver . . . . . c)                       | 66,50 |
| Reguline antimony . . . . . g)            | 10    |
| Iron . . . . . d)                         | 5     |
| Sulphur . . . . . f)                      | 12    |
| Copper and arsenic d) e) about . . . . .  | 0,50  |
| Extraneous matter from the mine . . . . . | 1     |

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95.

Considering the minute quantity of arsenic and copper, they can be reckoned only as casual ingredients; and the same holds good with respect to the quartzose matrix. But, as the antimony exists in that ore, intimately combined with the silver and sulphur, it must be considered as one of its essential constituent parts.

## FIFTH SECTION.

### White Silver-ore. (Weißgültigerz.)

NATURE has not confined herself to one certain determined law, in fixing the proportions that obtain among the constituent parts of the white silver-ore. This fact accounts for the difference of colour, lustre, and fracture, observed in the various specimens of this ore; which also, for the same reason, has been often confounded with the brittle vitreous silver-ore, the grey copper-ore, the compact plumose antimonial-ore (*dichtes Federerz*), and the compact galena, or potter's lead.

lead-ore (*bleyschweif*), &c. It is owing to this difference in the proportions of its component principles, that it is found, at one time, bright, and of a light grey; at another, of a lead-grey, and only glittering; of a fracture compact and even, sometimes finely grained, or even passing into the fibrous texture. Hitherto it has not been met with, except in lumps and disseminated.

Of its constituent parts, few particulars have been given by former authors. *Henkel*\* seems to be the first who enumerates them:—"Weißgültiges Erz," says he, "is properly a light, or bright-grey silver-ore, which yields 14 marks of that metal, if it be perfectly pure and compact. It contains, besides, a little copper, arsenic, and sulphur, of which, however, it is difficult to ascertain the proportions." It is probably upon this authority of *Henkel*, that late writers unanimously suppose the essential ingredients of this ore to be silver, copper, arsenic, and sulphur; to which *Cronstedt*, *Bergmann*, *Kirwan*, and several others, add iron. *Wallerius* mentions two varieties of it: the one without, the other with iron. *Lehman*, on the contrary, supposes some lead instead of iron.

Yet, how little these supposed constituent parts agree with the real ones, will be manifest from the following experiments, made with the two principal species of the white silver-ore.

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\* *Henkel redivivus*. Dresd. 1747. page 57.



A.

*Light white silver-ore.*

a) Among various minerals, dug in the mine *Himmelsfürst*, behind *Erbisdorf*, near *Freyberg*, I selected those that contain the bright white silver-ore in solid masses. From these, when pounded, I picked out a sufficient quantity of fragments, unmixed with the coarse-cubical galena, which accompanies this ore. It was easily levigated, and afforded a blackish powder, soiling the fingers.

b) Upon four hundred grains of this powder, I poured four ounces of nitric acid, of the strength before mentioned, and two ounces of water. After sufficient digestion in a gentle heat, the solution was decanted, and the residue again exposed to a warm temperature, with two ounces of that acid. This mixture I next diluted with eight parts of water, and continued to digest it for some time. I then separated the undissolved residue, consisting of a greyish-white powder, which, after washing and drying, weighed 326 grains.

c) The solution, which was nearly colourless, was combined with common salt, by which a considerable quantity of muriated silver was immediately produced. The next day were found over the horn-silver, which lay at the bottom of the vessel, tender needled crystals, which, upon closer examination, proved to be muriat of lead. On this account I boiled the whole precipitate in a large quantity of water, by means of which the muriated lead was redissolved, and separated from the muriat of silver, collected on

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the filter. This last, when reduced by fusion with soda, yielded  $81\frac{1}{2}$  grains of reguline silver.

d) What remained of the solution, together with the liquor obtained by the decoction of the horn-silver, I evaporated in part; and by adding a saturated solution of Glauber's salt, I obtained from it 45 grains of sulphat of lead, which, upon reduction, afforded 32 grains of lead in the metallic state.

e) The remaining part of the solution I now saturated with pure ammoniac; upon which a light-brown precipitate fell down, weighing 40 grains, whenedulcorated and ignited in a low heat. As that precipitate had the appearance of a mixture of iron and argil, I dissolved it again in nitric acid, and precipitated, first, the iron by means of Prussian alkali, and afterwards, by the addition of soda, a loose earth, which, when deficcated and ignited, weighed 28 grains, and, upon trial with sulphuric acid, was found to be *aluminous earth*. This, being subtracted from the above 40 grains, leaves 12 for the *oxyd of iron*, which may be estimated at nine grains of metallic iron.

f) After this, the residue, that remained from the solution of the ore dissolved in nitric acid (b), was subjected to a closer examination. I attempted to decompose it by muriatic acid, repeatedly poured upon it, and in every instance digested over it in a heat of ebullition. The process was rendered somewhat difficult by the fine needled crystals, which were deposited from the solution as soon as the heat fell below the boiling point. Similar crystals likewise shot on the paper, through which the solution, though yet boiling, was filtered, and I gradually re-dissolved them again in warm muriatic acid. At last there remained 51 grains of sulphur, leaving, after deflagration upon a test, two

5

grains



grains of a grey residue, one of which dissolved in muriatic acid, and was added to the preceding solution. The other grain was *siliceous earth*. The true quantity of the *fulphur*, therefore, amounted to 49 grains.

g) While the muriatic solution was cooling, it deposited a quantity of acicular crystals. These being separated, one half of the remaining fluid was distilled over in a small retort, and, from the solution thus concentrated, more crystals, similar to the first, were deposited. This treatment was continued until no more crystals would form. When these crystals, collected together, were mingled with twice their weight of black flux, and reduced in an assay-crucible, thinly lined with charcoal-dust, they afforded  $160\frac{1}{2}$  grains of lead. This lead, subjected to cupellation, emitted, at the first application of heat, a few antimonial vapours; it then fused quietly, and left a *button of silver*, weighing  $\frac{1}{3}$  of a grain. —This determines the proportion of *lead* at  $160\frac{1}{2}$  grains; from which, however, a trifling quantity should be deducted for the portion of *antimony* before mentioned; though it could not be well determined, besides that it could not weigh much above half a grain.

h) The fluid separated from the muriat of lead, concentrated, and covered with a large quantity of water, deposited its metallic part, which, in the form of a subtle, white powder, was only oxyded antimony, and being kneaded into a mass with soap, was reduced in a luted assaying-crucible, by means of black flux, into  $28\frac{1}{2}$  grains of pure *reguline antimony*. Some more small globules were found adhering to the lid of the vessel, of which I collected three grains; but still a small portion appeared to have escaped through the joinings, and for this reason, the true amount of antimony, which I obtained, may be reckoned at somewhat more than the  $31\frac{1}{2}$  grains.

Hence the product of the 400 grains of the *light white silver-ore*, here analysed, consisted of:

|                   |    |                  |                        |
|-------------------|----|------------------|------------------------|
| Silver            | c) | $81\frac{1}{2}$  | } $81\frac{5}{8}$ grs. |
|                   | g) | $\frac{1}{8}$    |                        |
| Lead              | d) | 32               | } $192\frac{1}{4}$     |
|                   | g) | $160\frac{1}{4}$ |                        |
| Reguline antimony | h) | $31\frac{1}{2}$  | grs.                   |
| Iron              | e) | 9                |                        |
| Sulphur           | f) | 49               |                        |
| Alumine           | e) | 28               |                        |
| Silex             | f) | 1                |                        |
|                   |    |                  | <hr/>                  |
|                   |    |                  | $392\frac{3}{8}$ grs.  |

Which, in one hundred parts, makes:

|                    |       |
|--------------------|-------|
| Silver . . . . .   | 20,40 |
| Lead . . . . .     | 48,06 |
| Antimony . . . . . | 7,88  |
| Iron . . . . .     | 2,25  |
| Sulphur . . . . .  | 12,25 |
| Alumine . . . . .  | 7     |
| Silex . . . . .    | 0,25  |
|                    | <hr/> |
|                    | 98,09 |

With respect to the argillaceous earth, found in the mixture of this ore, it may be questioned: Whether it be merely adventitious, or one of its constituent parts. If, at the same time, there had been discovered in it a proportionate quantity of the filiceous earth, they might both together be taken for a clayey matter of the mine, accidentally intermingled with that ore. But, considering the wide difference in the proportion of one part of silex to 28

of



of argil, the latter appears to be one of its actual constituent parts, though not essential.

B.

*Dark White Silver-ore.*

a) As of late this variety of the white silver-ore has but seldom occurred in pure masses in the Saxon mines, I sacrificed to analysis a specimen, which was procured in the year 1720, from the pit *Junger Himmelsfürst*, at Freyberg, and consisted of a solid, very pure, white silver-ore, of an inch in thickness, that crossed lamellar galena.

b) From two hundred grains of this pure ore, finely pulverized, I obtained a colourless solution by the affusion of three ounces of nitric acid, and an equal quantity of water. It was at first gently digested with the ore, then diluted with water, and, after a second digestion, strained through the filter. The silver, thus dissolved, was precipitated by means of common salt. The muriat of silver, thus produced, and dried in a warm temperature, amounted to  $24\frac{1}{2}$  grains, which are equal to  $18\frac{1}{2}$  grains of reguline silver.

c) Afterwards, on combining this solution of the ore with Glauber's salt, sulphat of lead was generated; the quantity of which, whenedulcorated and dried, amounted to 93 grains, or to 66 grains of metallic lead.

d) Liquid caustic ammoniac separated from the remaining fluid a brownish, loose precipitate, which, upon ignition, weighed  $6\frac{1}{2}$  grains, and, upon farther treatment, yielded  $4\frac{1}{2}$

grains of oxyded iron, (equal to  $3\frac{1}{2}$  grains of the reguline metal), and, besides, two grains of *aluminous earth*.

e) By adding nitric acid, a greyish-white residue of  $132\frac{1}{2}$  grains was left; which, when extracted with the necessary quantity of muriatic acid, left another residue of 52 grains; of which, after its sulphureous parts had undergone a slow combustion, only eight grains remained. Hence the proportion of *sulphur* consisted of 44 grains.

f) These eight grains, digested with muriatic acid, were dissolved by it, except  $1\frac{1}{2}$  grain of *siliceous earth*.

g) All the preceding muriatic solutions were then so far reduced by slow evaporation, as to form numerous crystals. After cooling, I caused the fluid which still remained to drain off from the crystals; any foreign matter, that might have adhered to them, I washed off with a mixture of one part of muriatic acid, and two of alcohol; and, after desiccation, I found their weight to be  $22\frac{1}{2}$  grains. They consisted of *sulphat of lead*, the metallic portion of which amounted to 16 grains.

h) The liquor, separated from them, still contained the *antimonial* ingredient of this ore. By dilution with a sufficient quantity of water, a white oxyd of antimony was thrown down; whose weight, upon drying at an increased temperature, proved to be 56 grains, and for which 43 grains of reguline *antimony* must be allowed.

It appears, then, that the dark, dull white silver-ore contains in one hundred parts:

*Silver*



|                             |           |       |
|-----------------------------|-----------|-------|
| Silver . . . . .            | b)        | 9,25  |
| Lead . . . . .              | c) and g) | 41    |
| Reguline antimony . . . . . | b)        | 21,50 |
| Iron . . . . .              | d)        | 1,75  |
| Sulphur . . . . .           | e)        | 22    |
| Alumine . . . . .           | d)        | 1     |
| Silex . . . . .             | f)        | 0,75  |

---

97,25

Consequently, this analysis of the above two varieties of the *white silver-ore* renders it evident, that it is neither *arsenic*, nor *copper*, but *lead* and *antimony*, which constitute the characteristic constituent parts of this species of metallic ore; and that the two last, for the future, should be mentioned as such.

Though these ores are usually accompanied by *galena*, the lead found in them should not, on this account, be considered as accidental; since it there exists in intimate mixture. It is a particular and remarkable phenomenon, and an anomaly in our knowledge of the elective attractions of bodies, that, even in the repeated digestions of the ore, neither the strong nor dilute nitric acid is capable to dissolve the whole of the admixed lead, and to destroy its combination with the antimonial ingredient.

Modern mineralogists have been induced, by the external and sensible differences of colour, lustre, and fracture, which exist between the above two varieties of the white silver-ore, to regard them as two distinct species, and have introduced the second into the systematical arrangement as the only genuine white silver-ore; separating from it the first, which is of a brighter hue, and has been ranked with the brittle vitreous silver-ore, treated of at *Set. IV.*

But as the reason for this classification was merely founded on some varieties of the external characteristic properties, it could only subsist as long as there was wanting a chemical investigation of these two varieties of the white silver-ore, as well as the chemical knowledge of their component principles, which depends on that enquiry.

This deficiency being removed by the present analytical processes, and it being demonstrated that the constituent parts of both are of the same nature, differing only in their proportions, they should be no longer described in systems of mineralogy as particular species, but only as varieties of *one* and the same species. For this reason, the *solid, brittle, vitreous silver-ore*, as it is called, should be again removed from the class of the last-mentioned species, and should resume the place which it formerly occupied among the *white silver-ores*.

#### SIXTH SECTION.

##### *Grey Silver-ore (Graugültigerz).*

That ore of silver which I here introduce with this new name, is erroneously called *white silver-ore (Weissgülden)*, at *Kremnitz* in *Hungary*, where it is dug up both in masses and in white quartz. This last appellation is the more improper, as, with regard to lustre and the colour of its fracture, it approaches nearer to the grey copper-ore (*Fahlerz*), than the white silver-ore (*Weissgültigerz*).

a) Three hundred grains of the fragments selected from the pounded ore, though not perfectly separable from the quartzose gangue,



gangue, with which they are firmly concreted, were levigated to a subtle powder, and digested with four times their weight of nitric acid. The digestion was renewed with the residue, in an equal quantity of the same acid; and the portion which still remained undissolved then assumed a greyish-yellow colour, and weighed 188 grains.

b) By the addition of muriat of soda to the bright-green nitric solution, its silver was thrown down; and this precipitate, collected and reduced by means of soda, yielded  $31\frac{1}{2}$  grains of metallic silver.

c) The silver being thus separated, I tried the solution for lead; but neither the neutral sulphats, nor free sulphuric acid, could discover the least sign of it.

d) After this I added caustic volatile alkali, so as to super-saturate the acid; upon which a brown-reddish precipitate, of a loose cohesion, appeared, that by ignition became of a black-brown, and weighed  $9\frac{1}{4}$  grains. It dissolved in nitric acid, leaving behind it half a grain of *siliceous earth*. Prussiat of pot-ash produced from the filtered solution a deep-blue precipitate of iron; and after this was separated,  $1\frac{1}{2}$  grain of *alumine* were obtained from it by means of soda. Therefore, subtracting the siliceous and argillaceous earths, the portion of *iron* attractible by the magnet amounted to  $7\frac{1}{4}$  grains.

e) To the solution, which had before been over-saturated with pure ammoniac, and exhibited a blue sapphirine colour, sulphuric acid was now added to excess. A polished piece of iron was then immersed into the fluid, from which it precipitated 69 grains of copper.

f) The

f) The above greyish-yellow residue (*a*) was now to be examined. I digested it with six times its quantity of muriatic acid in a heat of ebullition. When filtered, the residue which was left on the paper being first washed with muriatic acid, then with a little alcohol, and lastly dried, was found to weigh  $105\frac{1}{2}$  grains.

g) From the solution which was obtained by the last process, and was of a straw yellow, the greater part of the fluid was drawn off by a gentle distillation in a retort. The remaining concentrated solution then deposited some crystalline grains, which were carefully collected, and proved, upon inquiry, to be muriated silver, that afforded a bead of silver, weighing  $\frac{1}{4}$  of a grain. A large quantity of water being next poured into the solution, a copious precipitate subsided, weighing, after desiccation,  $97\frac{1}{2}$  grains. It proved, by every test, to be oxyd of antimony, for which, as I have found by comparative experiments, 75 grains of reguline *antimony* must be allowed.

h) The residue obtained at (*f*), weighing  $105\frac{1}{2}$  grains which comprised the sulphureous part of the ore, I exposed to a low heat, by which treatment the sulphur was consumed, and  $80\frac{1}{2}$  grains of siliceous earth remained. Hence the quantity of the *sulphur* was equal to  $25\frac{1}{4}$  grains.

i) The siliceous earth was next fused with four times its weight of black flux. The melted mass entirely dissolved in twice its quantity of water into liquor of flints; some minute particles of silver, weighing  $\frac{3}{4}$  of a grain, excepted. According to this, the proportion of *silver* amounted to  $79\frac{1}{2}$  grains.

Whence the constituent parts here obtained are :



|                   |    |           |                 |   |           |                                 |
|-------------------|----|-----------|-----------------|---|-----------|---------------------------------|
| Silver            | b) | . . . . . | $31\frac{1}{2}$ | } | . . . . . | $32\frac{1}{2}$ grains.         |
|                   | g) | . . . . . | $\frac{5}{4}$   |   |           |                                 |
|                   | i) | . . . . . | $\frac{3}{4}$   |   |           |                                 |
| Copper            | e) | . . . . . |                 |   |           | 69                              |
| Reguline Antimony | g) | . . . . . |                 |   |           | 75                              |
| Iron              | d) | . . . . . |                 |   |           | $7\frac{3}{4}$                  |
| Sulphur           | h) | . . . . . |                 |   |           | $25\frac{1}{4}$                 |
| Alumine           | d) | . . . . . |                 |   |           | $1\frac{1}{2}$                  |
| Silex             | d) | . . . . . | $\frac{1}{2}$   | } | . . . . . | 80                              |
|                   | i) | . . . . . | $79\frac{1}{2}$ |   |           |                                 |
|                   |    |           |                 |   |           | <hr/> 290 $\frac{1}{2}$ grains. |

But as the siliceous earth does not belong to the real mixture of the ore, but only arises from the admixed particles of quartz, it follows, that, when these are excluded from the computation, the true constituent parts of the grey silver-ore here examined, are, in the *hundred*, as follows :—

|                   |           |             |
|-------------------|-----------|-------------|
| Silver            | . . . . . | 14,97 parts |
| Copper            | . . . . . | 31,36       |
| Reguline Antimony | . . . . . | 34,09       |
| Iron              | . . . . . | 3,30        |
| Sulphur           | . . . . . | 11,50       |
| Alumine           | . . . . . | 0,30        |
|                   |           | <hr/> 95,32 |

As, therefore, the foregoing analysis plainly shews that no lead is contained in this *silver-ore* from *Kremnitz*, it cannot be any longer classed with the white silver-ores. For the same reason it would be equally improper to reckon it among the grey copper-ores : but, from the considerable proportions of noble metal which it contains, it has a just claim to the rank of a silver-ore, more so than even the  
white

white and poorer ores of that metal. Therefore, from analogy with the generic appellation, I have given it the name of *grey silver-ore*.

When it is considered that all the silver procured from the ores in Lower Hungary contains a portion of gold, and that this portion usually amounts to one drachm (*4 denarien*) in the mark of the refined silver, which, in *Kremnitz*, is coined into money, there remains no doubt that the ore here analysed likewise contains gold, as, indeed, some traces of it appeared in the course of this investigation. But it would have required a distinct process, performed too with a greater quantity of the ore, to have ascertained the proportion of gold contained in it; which, however, was beyond the limits of the present inquiry.

According to an information given to me as authentic, this ore is said likewise to contain mercury. Therefore, though no indication of this metal occurred to me during those experiments, I thought it worth while to institute a particular inquiry on that point. For this purpose I mingled 200 grains of the ore with 100 of quick-lime; and having put this mixture into a small retort, connected with a receiver, filled with water, I exposed the vessel to the fire, increasing the intensity of heat until it became red-hot: but no perceivable trace of mercury appeared.

## SEVENTH SECTION.

### *Native Amalgam of Silver.*

Besides the sulphurated ores of silver, various other metallic mixtures are found in the mineral kingdom, in which



which the silver, unaccompanied by sulphur, enters as a constituent part. To these, among others, belongs the solution of silver in mercury, or the native *silver-amalgam*, which occurs chiefly in the quick-silver mines, and, in various forms, in the Duchy of *Deux-ponts*.

In order to ascertain the proportion of these two metals to each other, I employed the amalgam, which is found in solitary, garnet-like crystals in the mine called *Vertrauen auf Gott*, at *Moschellandsberg*. Some pure crystals of this amalgam, weighing together exactly  $33\frac{1}{2}$  grains, were inserted into a barometer tube, of a diameter somewhat larger than usual, the lower end of which had been closed by fusion. This end being placed in sand, within a small crucible, I applied heat to it, increasing its intensity gradually and slowly to the degree of ignition. After cooling, I cut off the lower end from the tube, and found that it contained the silver, which had undergone ignition, in its former crystalline form, and weighing 12 grains. On collecting the mercury that had been sublimed in the tube, I obtained 21 grains. Therefore, since the deficiency of  $\frac{1}{2}$  of a grain may be reckoned as a loss of quicksilver, the following will be the proportion of the parts in one hundred of this *crystallized amalgam of silver*: namely,

|         |   |   |   |    |
|---------|---|---|---|----|
| Silver  | . | . | . | 36 |
| Mercury | . | . | . | 64 |

---

100

## EIGHTH SECTION.

*Arsenical Silver.*

Another example of a metallic mixture, containing silver free from sulphur, is the native *arsenical silver*. Its proportion of silver varies from a few half ounces to several marks (of 8 ounces) in the centner, or one hundred pounds. Among the richer sorts of this ore, I selected the specimen, the analysis of which is here given, and which was dug up from the mine *Samson*, at *Andreasberg*. Its gangue consists of white, coarsely-lamellated calcareous spar, in which the arsenical silver is contained, partly in lumps, partly disseminated in coarse grains, but without any other kind of extraneous ores.

a) At first I separated from the general mass, coarsely pounded in the mill, those pieces of calcareous spar which contained no portion of metal. Then I continued pouring distilled vinegar on the picked ore, till the calcareous spar that still adhered was entirely dissolved and separated. Lastly, when the ore had again become dry, I reduced it into a fine powder.

b) Upon two hundred grains of the ore, thus purified and pulverized, I poured nitric acid of moderate strength, by which it was attacked with great vehemence. When sufficiently digested, the solution was separated, by digestion, from the dirty yellow residue, which, upon drying, weighed 71 grains.

c) On combining it with common salt, dissolved in water, muriat of silver precipitated from the solution. This  
horn-



horn-silver was then freed from moisture, and fused in a silver-crucible over a gentle fire; during which process it emitted some arsenical vapours. Its weight was 28 grains, equal to 21 grains of *metallic silver*.

d) The silver being thus removed, I saturated the solution with vegetable alkali, procured from tartar. A light-red and very intumescent precipitate fell down, which, on drying, was rendered of a deep-brown. Ignition made the brown colour disappear, and the precipitate now exhibited a light greenish-grey powder, inclining to white, and which weighed 160 grains. Being convinced that it was arseniated iron, I put it on a roasting test, mingled with one fourth part of powdered charcoal; and applied a low red-heat. By this treatment the arsenic became revived, and escaped in white vapours. The remaining iron was again repeatedly roasted, with the addition of charcoal-dust, till no arsenical smell could be any longer observed. The iron which at last remained had a black colour, weighed 106 grains, and perfectly obeyed the magnet.

e) The 71 grains (b), that continued undissolved in the nitric acid, were digested with muriatic acid, and towards the end were once more combined with a few drops of the nitric acid. Nearly all the powder was dissolved, excepting a small residue, coagulated like curds of cheese; which proved to be muriated silver, and by reduction with soda furnished a button of *silver*, of  $4\frac{1}{2}$  grains.

f) By dilution with water, this muriatic solution was rendered turbid, without any precipitation. But by saturating it with salt of tartar, a yellowish-green sediment appeared, which, when collected, dried, and ignited, was found to weigh 32 grains. Upon dissolving it again in a small quantity of muriatic acid, a white precipitate was produced

duced by the affusion of water; the quantity of which, when dried in a warm temperature, amounted to  $10\frac{1}{2}$  grains. On farther trial, it proved to be unquestionably an antimonial oxyd; still containing, however, a slight trace of arseniated iron. I estimate that oxyd at 8 grains of *reguline antimony*.

g) What remained of the muriatic solution afforded, by combination with the above vegetable alkali, a precipitate, which, when dried and roasted, like the preceding (*d*), with pulverized charcoal, yielded 18 grains of *oxyded iron*.

h) Desirous of assuring myself of the absence of sulphur, I subjected 200 grains of the powdered ore to sublimation, in a small retort. Nothing but pure reguline arsenic was raised; which, as usual, fixed in the neck of the retort, in the form of a crust of a metallic lustre, composed of an accumulation of small crystals.

i) It is then evident, that this ore consists of silver, iron, arsenic, and antimony. However, when we reflect that the arsenic, during the treatment of the ore with acids, combines with oxygen; and farther, that part of it is driven off in the oxyded state, on the process of roasting, and that part of it is taken up by the water employed for washing the precipitates, the acid of arsenic being of easy solution in water, it is obvious that there exists a degree of uncertainty in the attempt to ascertain, with accuracy, the proportions in which those ingredients are united. Nevertheless, the proportion of arsenic may be computed, with propriety, from the loss of weight requisite to make up the whole weight of the three remaining constituent parts, in the following manner:



|           |           |    |   |           |     |
|-----------|-----------|----|---|-----------|-----|
| Silver c) | . . . . . | 21 | } | . . . . . | 25½ |
| e)        |           | 4½ |   |           |     |

Iron,

Oxyd of iron attractible

|               |    |     |   |     |
|---------------|----|-----|---|-----|
| by the magnet | d) | 106 | } | 124 |
|               | g) | 18  |   |     |

which gives of metallic iron . . . . . 88½

Reguline antimony . . . . . 8

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122

The arsenic, therefore, would make

(200—122=78) . . . . . 78

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200

However, since, in the processes of chemical analysis of this as well as of other species, some loss always unavoidably occurs in the sum of the products, amounting from 2 or 3 to 5 or 6 in the hundred, regard must here be had to this circumstance. Therefore, if the mean number of the loss, which is 4, be subtracted, 70 will be left for the arsenic.

Hence, according to these premises, the *arsenical silver* examined in this analysis contains, in an hundred parts,

|                       |       |
|-----------------------|-------|
| Silver . . . . .      | 12,75 |
| Iron . . . . .        | 44,25 |
| Arsenic, . . . . .    | 35    |
| Reguline antimony . . | 4     |

---

96

Besides the above eight species of silver-ores, the analysis of which have made the subject of the present essay, other

other kinds of argentiferous ores and metallic mixtures occur. But the greatest part of these cannot be fairly considered as species of the genus of silver-ores; because the proportion of the noble metal which they contain is too inconsiderable, when compared with their other constituent parts.

In general, I should not wish to recommend the method hitherto used in the systematic arrangement, of denominating ores by the constituent part, which is of the greatest mercantile value; though, on the other hand, I do not venture to assert, that, at the present period, the *predominant constituent part* alone should serve as the principle, upon which to establish the classification of fossil bodies. If it were so, we should only retain under the genus of silver (besides the *native silver*) the *corneous*, the *red*, the *vitreous*, and *brittle vitreous silver-ores*; together with the black silver-ore (*silver-mulm*), which I had no opportunity to examine. And, on the contrary, the *white silver-ore* would then necessarily come under the genus of lead; the *grey* under that of antimony; the *silveramalgam* under that of mercury; and the *arsenical silver* under the genus of iron.

It is only by increasing our knowledge of the chemical composition of individual species of fossils that we shall be able to erect, on the relics of the present system of mineralogy, another, which shall possess a more solid foundation, and shall be more conformable to nature.



## X.

## EXAMINATION

OF THE

## ORIENTAL LAPIS LAZULI.

THOUGH the researches of Marggraf have refuted the opinion, formerly received, that the blue colour of the *Lapis Lazuli* originated from an admixture of copper; and though it has been demonstrated that the colour of this fossil is owing only to iron, yet its other constituent parts have not yet been determined with due accuracy. For this reason, I thought that a farther examination of it would not be superfluous.

*Marggraf*\* mentions, indeed, and very justly, *lime*, *gypsum*, and *silica*, as the other constituent parts of the lapis lazuli, besides a quantity of *iron*: but this account is still incomplete, as he takes no notice of their respective proportions, and has, besides, entirely overlooked the *aluminous earth* which it contains.

*Rinmann*† assures us, that this stone, besides iron, calcareous earth, and quartz, contains also *fluoric acid*. Never-

\* *Marggraf*, Chim. Schriften I. Theil. Berlin, 1768, page 121.

† *Rinmann*, Geschichte des Eisens, 2 B. Berlin, 1785, page 136.

theless, I could not ascertain the presence of the latter. *Rinmann's* supposition was probably occasioned only by the phosphorescent light which issues from the lapis lazuli, when heated.

*Cronstedt*, and others likewise, suppose the existence of silver in this mineral, amounting to two ounces in 100 pounds; but neither could I discover any clear indication of this ingredient. I chose, for the following inquiries into the nature of the lapis lazuli, a pure specimen of a deep-blue; and I first endeavoured, as much as possible, to free the fragments from the white spots, and the particles of sulphur-pyrites with which this stone is always mixed.

a) Hundred parts of lapis lazuli lost two parts in weight, by being ignited for half an hour in a porcelain crucible. Its colour sustained no change.

From this considerable permanence of the beautiful blue colour, I was induced to try whether it would admit of being employed as an enamel colour, especially as *Bergmann* had already conjectured that the Chinese and Japanese probably used the lapis lazuli to impart the blue colour to their porcelain. With this view, I caused the powder, finely ground with a suitable flux, to be put upon porcelain, and had it baked in an enamelling furnace. My expectation, however, proved abortive; for the colour was altered, and had passed to an ash-grey.

b) But in a stronger and more continued fire, the lapis lazuli becomes completely vitrified, and loses 12 per cent; as has been already mentioned in No. 51 of my Essay on the Habitudes of various Species of Earths and Stones in Fire. The two parts that escaped from the hundred, during ignition for half an hour, cannot well be taken for any thing



thing else than water. But the other 10 parts, which the stone loses in a more intense heat, probably consist of carbonic acid; since the effervescence of the lapis lazuli, when covered with any acid, weak as it is, shews that a part of its calcareous ingredient is dissolved in that menstruum.

c) Two hundred grains of finely levigated lapis lazuli were digested in a retort with muriatic acid, weakened by an equal quantity of water. The blue colour of the pulverized stone gradually turned to ash-grey. When the mixture had reached a boiling heat, the powder was acted on with greater vehemence by the acid, and, after some ebullition, it formed a cheesy-coagulum. I then diluted it with more water, added one part of nitric acid, and kept it boiling till the insoluble residue had assumed a white colour. The solution, afterwards separated by filtration, was of a pale yellow.

d) The residue had a sandy appearance, and weighed 138 grains after drying. It was subjected to ignition with three parts of caustic, or pure pot-ash. The greenish mass which resulted thence, when softened with water, afforded a colourless solution, from which muriatic acid, added to excess, precipitated *siliceous earth*, weighing 57 grains when ignited.

e) This same solution (d), mixed with the above (c), and decomposed in a boiling heat by carbonat of pot-ash, yielded a yellowish-white precipitate, which, upon desiccation, weighed 221 grains, and entirely dissolved in muriatic acid.

f) Caustic ammoniac threw down from this solution a gelatinous precipitate, which, when digested with caustic

alkaline lye, was not totally dissolved, but left a yellowish-white residue, of 113 grains, in its dry state.

g) By combining the liquid that remained from the precipitation by ammoniac, with carbonat of pot-ash, in a boiling heat, 59 grains of carbonat of lime, or mild *calcareous earth*, were obtained.

h) Upon the 113 grains, not taken up by the caustic lye, I poured dilute sulphuric acid. The mixture coagulated in heat to a gelatinous consistence. When covered, and digested with a large proportion of water, there separated from it *siliceous earth*, the quantity of which, after being heated to redness, was 29 grains.

i) After the filix had been separated, the solution was mixed with ammoniac, and the precipitate thus formed was conveyed, while yet moist, into boiling caustic lye. A brown flocculent precipitate remained, which weighed, when dry, 13 grains. After they had been dissolved in muriatic acid, caustic ammoniac precipitated *oxyd of iron*, weighing 6 grains. After desiccation, by adding carbonated ammoniac to the remaining fluid, 5 grains more of *calcareous earth* were thrown down.

k) The alkaline solution (f) and (i) were then saturated with muriatic acid. By this all that the alkali had taken up was separated; and this, when re-dissolved, by an additional portion of the same acid, I again precipitated by carbonated pot-ash. On re-dissolving this last precipitate, in dilute sulphuric acid, there appeared another portion of filix, which, after ignition, was found to weigh 6 grains. The sulphuric acid, when poured off, and combined with a due proportion of pot-ash, afforded crystals of alum, which were re-dissolved, and their *aluminous earth* precipitated by



by means of mild, or carbonated alkali. After the alumine had been properly purified, deficcated, and exposed to red heat, its weight amounted to 29 grains.

1) I had before convinced myself, that in the lapis lazuli the whole of its calcareous earth is not combined with carbonic acid, but a portion of it with the sulphuric acid. For this purpose I boiled a portion of pulverized lapis lazuli with a large quantity of water; which, when filtered, had an opaline appearance. Muriated barytes being then added as a test, some sulphat of barytes was formed. In order to discover the proportion of the sulphat of lime, or gypsum, contained in this stone, I took the fluid remaining from the precipitate mentioned at (c), together with the edulcorating water, and, after super-saturation with muriatic acid, I examined it with a solution of muriat of barytes. The result was a precipitation of sulphat of barytes which, collected and highly dried, amounted to  $19\frac{1}{2}$  grains.

It was reasonable to conjecture, that not only the gypsum contained in the lapis lazuli, but also an accidental admixture of sulphat of pot-ash, in the caustic and mild alkali employed in the processes (d) and (e), might have contributed to the formation of the sulphated barytes. Therefore, to ascertain this point, I dissolved a similar quantity of each, adding then muriatic acid, so that the acid predominated; and, lastly, I combined the whole with muriat of barytes. In the result, there appeared  $1\frac{1}{2}$  grain of sulphat of barytes. collected with care. An equal quantity, therefore, is to be deducted from the above  $19\frac{1}{2}$  grains. On this account, the above-mentioned 18 grains of sulphated barytes were the proper scale, or measure, by which to determine the proportion of the gypsum sought for in the present instance; and, calculating upon this ground, it followed, that the above 200 grains of decomposed lapis lazuli contained

8,18 grains of free sulphuric acid of 1,850 *spec. grav.*; or, if taken in combination with the lime which enters into that stone, 13 grains of gypsum. This computation is founded on the results of my experiments: *first*, that, dis- regarding minute fractions, 100 parts of sulphuric acid of the above-mentioned specific gravity, when saturated with barytes, yield 220 of sulphat of barytes; and, *secondly*, that the same quantity of sulphuric acid, when saturated with calcareous earth, forms 160 parts of gypsum: observing, however, that 100 parts of crude calcareous earth, or carbonat of lime, are required to saturate the acid; but only 55 parts of pure, or burnt lime.

Consequently, these 200 grains of *Lapis Lazuli* give the following remote constituent parts:

|                       |           |             |                |
|-----------------------|-----------|-------------|----------------|
| <i>Lime</i>           | <i>d)</i> | 57          | } . 92 grains. |
|                       | <i>b)</i> | 29          |                |
|                       | <i>k)</i> | 6           |                |
| <i>Silex</i>          | <i>g)</i> | 59          |                |
|                       | <i>i)</i> | 5           |                |
|                       |           | 64, ignited | 35             |
| <i>Alumine</i>        | <i>k)</i> |             | 29             |
| <i>Oxyd of iron</i>   | <i>i)</i> |             | 6              |
| <i>Sulphuric acid</i> | <i>l)</i> |             | 8              |
| <i>Carbonic acid</i>  | <i>b)</i> |             | 20             |
| <i>Water</i>          | <i>a)</i> |             | 4              |
|                       |           |             | 194            |
|                       |           | Loss        | 6              |
|                       |           |             | 200 grains.    |

But



But since the calcareous earth, in the present subject of inquiry, is combined partly with sulphuric acid, partly with the carbonic, the following must be reckoned as the *proximate constituent parts* of the lapis lazuli:

|                                           |       |
|-------------------------------------------|-------|
| <i>Silex</i> . . . . .                    | 46    |
| <i>Alumine</i> . . . . .                  | 14,50 |
| <i>Carbonat of lime</i> . . . . .         | 28    |
| <i>Sulphat of lime (gypsum)</i> . . . . . | 6,50  |
| <i>Oxyd of iron</i> . . . . .             | 3     |
| <i>Water</i> . . . . .                    | 2     |

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100

The reason of this exact agreement of the sum of the constituent parts with the weight of the whole, is, that I have supposed the carbonat of lime to be *completely* saturated with the carbonic acid; which, however, does not seem entirely to be the case.

## XI.

## EXAMINATION

OF

*A SMALT-BLUE FOSSIL, from Vorau\**

AMONG the mineralogical notices, given in a letter from Vienna, inserted in the third volume of the *Observations and Discoveries in Natural History*, page 352, mention is made of a newly-discovered blue fossil from *Vorau*, in Austria. It was, at first, taken for *native smalt*, then for *native Prussian-blue*, and, lastly, for *mountain-blue*, or azure copper-ore.

This fossil is of a deep smalt-blue, accompanied with a grey-white quartz, of an imperfectly conchoidal fracture, (*Fettquarz*), with which it is firmly concreted, and crossed by a band of *shistose mica*, from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch thick, consisting of grey-white granular quartz, and a little mica of a silvery-white. It partly forms the seam, or joint (*salband*) of this small vein; partly it is finely diffused through the quartz, and sometimes it approaches to the size of a hazel-

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\* *Beobachtungen und Entdeckungen aus der Naturkunde* 4 Band. Berlin, 1792. Seite 90.



nut. When in the latter state, a crystalline form of quadrilateral flattened columns, or tables, is observed; though, on account of the quartz, which is perfectly concreted with it, the exterior, unbroken surface only, in some parts, exhibits the crystalline form. On these facets the fossil is even, and of a moderate lustre; but in the fracture, which is compact and rough, it is only glittering. It is opaque; its streak of a somewhat lighter blue; its hardness nearly that of quartz.

No sign of any volcanic product presenting itself in this fossil, it was obvious, from the very mode of its appearance, that it could not, by any means, be a native smalt: for, must not the agency of fire have been present, to form a stony matter, naturally coloured blue by means of *cobalt*?

The following short narrative of my researches concerning this fossil, will also prove, that it is as far from being a *mountain blue*, or containing oxyded *copper*; notwithstanding that this is given as the result of the chemical experiments made with it at Vienna.

Finding that all the acids which I poured upon this mineral, previously reduced into fine powder, and freed as much as possible from the associated quartz, would not attack it with the requisite force, I subjected it to a low red-heat, combined with twice its weight of pot-ash, procured from tartar. After refrigeration, I observed that the blue colour had entirely disappeared, and the mass had assumed a yellowish-white. When this had been triturated, softened in water, then saturated to excess with nitric acid, digested and filtered, there remained undissolved *siliceous earth*. The solution had no colour. In one part of it I immersed polished iron; but neither copper, nor any other metallic

substance would precipitate. To the remaining portion prussiat of pot-ash was added, and thus a deep-blue precipitate was produced, which, after ignition, was attracted by the magnet. From the solution, separated from this last by filtering, liquid caustic ammoniac threw down some *aluminous earth* in a slimy state. But the remaining fluid suffered no change, on the addition of carbonat of pot-ash.

*Silex*, *alumine*, and *oxyded iron*, are then the constituent parts here discovered. But their respective proportions remain to be ascertained by new experiments, to be performed with a greater quantity of this fossil.

As, therefore, not the slightest trace of copper can be found in this fossil, it is obvious that it cannot in any respect be considered as a mountain-blue.

Nor can I take it for a native Prussian blue, which it was considered to be, in consequence of an inquiry made into its nature at Chemnitz. Its portion of iron affords no argument to the contrary; and the grounds of my opinion rest upon the following observations.

1. a) The native Prussian blue is found only in moorish grounds or fens, and in thin strata. It occurs immediately under the vegetable mould, and appears in the form of a loose white earth, that becomes blue only when exposed to air.
- b) This blue fossil, on the contrary, is concreted with a hard vein of quartz, which is inclosed in a stony matter of equal hardness. Besides, its blue colour shews itself directly on every recent fracture; which indicates that the fossil was previously possessed of it.

2. a)



2. a) Native Prussian blue is immediately deprived of its colour by fire; at first it becomes brown, then of a brick-red, and lastly it melts into globules of a metallic lustre.

b) The fossil from Vorau falls instantly in pieces, when urged by the fire. Its cohesion is thereby loosened, and it assumes the form of a light-grey flocculent earth; but without shewing the least disposition to fuse.

3. a) With borat of soda, and with the phosphats, the native Prussian blue runs into a black untransparent scoria.

b) But the fossil from Vorau yields, when fused with borax, a clear, faint, topaz-yellow glass; and with a neutral phosphat\*; a clear, colourless glass.

4. a) The native Prussian blue directly liquefies in acids, when poured upon it.

b) On the contrary, the fossil from Vorau is with difficulty acted upon by acids.

5. a) Caustic alkaline lye instantaneously changes the colour of the native Prussian blue into a brown.

b) But the colour of the above fossil is not at all altered by it.

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\* The author constantly uses the expression *Phosphorsalz*, whereby *concrete phosphoric acid* might be understood: but most probably he means a neutral phosphat, and especially the *phosphat of soda*, which, on account of its property of promoting fusion in an eminent degree, is chiefly employed by mineralogists and chemists in examining substances with the blow-pipe.—Hence, the translator substitutes, in all similar cases, the term *neutral*, or *alkaline phosphat*. Transf.

In the native Prussian blue, the oxyd of iron is combined with phosphoric acid; as I have proved in another place\*. But it is still unknown, by what substance the oxyd of iron, contained in the fossil from Vorau, is modified so as to acquire the blue colour.

Another instance of a similar blue colour imparted by iron, is afforded by the *Oriental lapis lazuli*. It differs, however, from the preceding, in this, that its blue colour is considerably more permanent in the fire; for, so long as the stone is but moderately ignited, its colour continues unaltered, and is changed only when the stone is urged by a stronger heat, and is brought into the state of fusion. The lapis lazuli is also distinguished from the fossil from Vorau, besides its other constituent parts, by a proportion of calcareous earth, which is the cause of its melting in fire.

If the above fossil likewise contained lime, I should not hesitate to range it as a variety of the lapis lazuli; as has been already done by Mr. Stütz†, with the name of *spurious lapis lazuli*. Perhaps may the denomination *lazulite* be not quite improper.

Note. I have once mentioned that fossil, as a particular species of ferruginous earth, or oxyded iron, with the name of *iron-blue from Vorau*; but its proportion of iron seems to be too small to entitle it to that place.

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\* Chemische Annalen. 1784. 5tes Stuck. Seite 396.

† Neue Einrichtung der K. K. Naturaliensammlung zu Wienn. Wienn, 1793. Seite 49.



## XII.

## CHEMICAL EXAMINATION

OF THE

## CIRCON, OR JARGON OF CEYLON.

—  
FIRST SECTION\*.

AMONG the rough or uncut precious stones coming from Ceylon, there occurs a particular genus, hitherto little noticed; which is distinguished from other gems by the following characters.

Its colour consists of various shades of pale yellow-green, and reddish, altogether inclining to a dim smoke-grey. Externally, a greasy gloss is observed, and it feels smooth. The size of the individual stones is inconsiderable; commonly 20 or 30 of them weigh only one drachm. The primitive figure of their crystals is a rectangular four-sided column (*parallelepipedon*), with tetrahedral terminations, the surfaces of which rest on those of the column. However, this form of crystallization is distinctly perceptible in

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\* Auszug aus den Beob. u. Entdeck. aus der Naturkunde. 3 B.  
2 St. Berlin, 1789.

very

very few specimens only; as for the greatest part they are merely loose, minute, rounded grains (*abgerundete geschiebe* \*.)

But this kind of gems is eminently distinguished by its specific gravity, which I have found to be 4,615†.

*Romé de l'Isle* was the first, to my knowledge, who mentions these gems as a particular species of stones; giving them the name, *Jargon of Ceylon*, and stating their weight, according to *Briffon's* experiments, at 4,416. Other mineralogists and writers, who notice this stone, class it—some with the sapphire, others with the topaz, others with the ruby, others with the diamond, and some with the hyacinth. But *Werner* has assigned to it a peculiar place in the mineralogic system, immediately under the diamond, and the chrysoberyl, and called it *Zircon* (*Silex cirronius*.)

The jargons do not lose much of their weight by ignition; for, upon igniting 300 grains for the space of one hour and a half, and with the greatest intensity of heat, I found the loss to be only one fourth of a grain. This ignition I repeated three times, and quenched them after each process in water. The stones became by this risty: the brighter ones lost their smoke-grey appearance, and were rendered similar to cloudy white-grey quartz; but some of the darker specimens, as well as some parts of the brighter, turned reddish. Their natural hardness, however, did not seem to have been impaired.

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\* A more circumstantial description has been given by *Emmerling*, in his *Lehrbuch der Mineralogie*, I. Th. Gießen, 1793; and by *Widenmann*, in his *Handbuch der Mineralogie*, Leipzig, 1794.

† Yet I have afterwards found a difference in the specific gravity of the various species; however, the least weight that I observed was as high as 4,530.



## A.

a) By way of a preparatory analysis, 200 grains of jargon were levigated in a flint-mortar to a very subtle powder of a white colour, inclining to a pale flesh-red, which I mingled with equal parts of carbonated pot-ash, exposing it to a red-heat for one hour in a silver-crucible. It then formed a conglutinated mass, which, upon trituration, I saturated to excess, and digested with muriatic acid. But this did not at all appear to attack it, as I obtained again the jargonic powder without the least alteration, and with the loss of only half a grain.

b) For this reason I afterwards blended the same powder with six times its quantity of the above alkali, prepared from tartar, and ignited it strongly during five hours. The mass was rendered compact, and brought to the point of fusion: yet, when softened with water, and digested with muriatic acid added to excess, the powder of the stone was likewise found but little altered; and, after washing, drying, and ignition, I recovered it with no more loss than two grains.

c) Upon this, I once more added 1200 grains of the above alkali, and kept the mass in an ignited state, until it actually fused; which, after being again super-saturated with muriatic acid, left behind it 197 grains of undecomposed jargon.

d) I next put this powder into a retort, and poured upon it five times its quantity of strong sulphuric acid, adding to it one ounce of water; and when the liquor had been dis-

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tilled

tilled off to dryness, I softened the residue with water. But even by this process the stone underwent no observable change. The residue, when lixiviated and dried, resembled, as before, a fine sandy powder, and weighed 196 grains. From the acid fluid, saturated with alkali, one grain of a white earth fell down.

The obstinacy with which the jargon resisted every attempt to decompose it in the above manner, abated my ardour in pursuing farther this experiment. But, having in the mean time become acquainted with the powerful efficacy of caustic fixed alkalis in loosening the cohesion of particles in the various species of gems, I resolved to employ them also for the jargon, and proceeded to the following new experiment.

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B.

a) *Two hundred grains* of finely pulverized jargon were ignited for two hours in a silver-crucible, with four times their weight of caustic soda, and with such an intensity of heat, that the mass continued in a state of pulpy or thick fusion. Upon refrigeration, the mass proved to be very hard, and was gradually softened by repeated affusion of boiling water. The alkali seemed to have totally lost its former causticity, the solution tasting like a weak carbonated lixivium. When it had been sufficiently super-saturated and digested with muriatic acid, I did not observe that any siliceous earth separated; and the undissolved residue remained behind on the filtering paper in the form of a fine sand-like powder, weighing, after desiccation and ignition, 172 grains.

b) That



b) That residue, when again treated in the same manner with four times its weight of caustic soda, afforded a very firm porous mass, which, after being digested with muriatic acid, in the manner related, left behind 148 grains of jargonic powder.

c) The same process of adding to it four times its weight of caustic soda, and subsequent digestion in muriatic acid, was repeated with this last. After this treatment, there still remained 127 grains.

d) This, treated again for the fourth time in the same manner, left 97 grains.

e) As my stock of caustic soda was now exhausted, I prepared, instead of it, a caustic vegetable alkali, and added to the above undecomposed 97 grains of jargon six times their weight of the above alkali, and kept the mass, during several hours, in as intense an ignition, as the silver-crucible was able to bear without melting. However, its fusion went on but slowly, and was of a pulpy consistence. Even boiling water would but difficultly liquefy the refrigerated mass. But, when it had been saturated to excess, and digested with muriatic acid in the degree of boiling heat, a total solution of the jargon ensued.

f) I now poured together all the several preceding solutions. The whole of them exhibited a transparent fluid, but somewhat opalescent, and with a few light flocculent particles floating in it. I then saturated this liquor with carbonated, or mild pot-ash. The earth, which separated by this management, gave to the mixture an appearance of milk. But when collected on the filter, and washed, it first assumed the form of paste made of starch, and afterwards dried up to lumps of a vitreous appearance, and of a

whitish colour, verging upon the grey-green. The fluid filtered off from it, together with the washings, still deposited in a warm temperature a small portion of earth, which I added to the above precipitate.

g) This precipitate contained now all the constituent parts of the jargon under examination, but deprived of their native cohesion. *One half* of it I digested with one ounce of strong muriatic acid, in a heat of considerable intensity, and thus I obtained a turbid yellowish solution, from which the undissolved part slowly subsided upon dilution with water. After the superincumbent liquor had been decanted, and the residuum digested with an equal quantity of boiling muriatic acid, I filtered the solution, and dried the undissolved residue, which still remained.

b) As, in this instance, it was my principal design to discover, whether any calcareous earth was present, I precipitated the dissolved portion from the muriatic solution by means of caustic ammoniac. It fell down as an extremely loose substance, resembling a transparent slime. But neither carbonated ammoniac, nor carbonated pot-ash, would produce the least turbidness, when added to the separated clear liquor. This shews, that it contained no calcareous earth; which was also confirmed by several other tests or re-agents employed for that purpose.

i) Upon the *second half* of the above precipitate (g) I affused a triple quantity of concentrated sulphuric acid, and abstracted it again by distillation to dryness. From the residual mass again softened with water, and which looked like dissolved starch, I separated the undissolved part by filtration. But the filtered sulphuric solution, which was as limpid as water, when combined with various precipitating media, exhibited



exhibited precisely the same phenomena with those shewn by the foregoing solution, prepared with muriatic acid.

k) The whole of the earth, which remained from both solutions (g) and (i), weighed, after ignition,  $86\frac{1}{2}$  grains, and resembled a fine sandy powder. It was then mingled with four times its weight of carbonated pot-ash, and subjected to ignition in a silver-crucible, until it entered into complete fusion. When the mass was again softened in water, it was found still hard, and of difficult solution. However, a very subtle, heavy, and, apparently, tenacious earth, was deposited, which, collected and ignited, was found to weigh  $28\frac{1}{2}$  grains.

l) The clear and colourless alkaline lixivium I divided into two parts. *One half* of it I saturated with muriatic acid; by which treatment, a white, puffy, gelatinous earth separated, no portion of which, however, would re-dissolve, by adding a superabundant quantity of the same acid. The *other half* I first diluted with plenty of water, and then gradually saturated it to excess with muriatic acid. It continued clear and limpid; and by this I was convinced, that the above was *merely siliceous earth*; which, therefore, after deducting the  $28\frac{1}{2}$  grains of earth from the  $86\frac{1}{2}$  grains that were fused with the pot-ash (k), amounted to 58 grains.

*Note.* This is the order of examination in which I proceed, with respect to those earths, which, on analysis, I have some reasons to consider previously as belonging to the siliceous genus. By this method I most surely avoid the error, perhaps not unfrequent, of immediately calling any earth, that on the first attempt does not appear to dissolve in acids, merely siliceous. I likewise largely dilute with water the alkaline solution of the siliceous earth, and combine it to excess with any acid—in which case, however, no precipitate ensues, because the sili-



aceous earth thus circumstanced is really soluble in water.)— And when upon this I evaporate it to dryness, with the assistance of heat, and soften again the dry salt with water, I find the siliceous earth, that was before held in solution, at the bottom of the vessel, in the form of fine crystalline grains of sand.

m) Those  $28\frac{1}{2}$  grains of earth, that were left behind on the treatment with alkali (k), I digested in a boiling heat, with an abundance of nitro-muriatic acid. A residue was left, weighing, upon ignition, 16 grains.

n) These undissolved 16 grains, blended with six parts of caustic pot-ash, were exposed for some hours to a red heat. The colourless fluid, which was filtered off from the mass when again liquefied with water, was not rendered turbid by the addition of sulphuric acid. But when exposed to a raised temperature, it formed a gelatinous mass, which, after thorough desiccation, and the separation of the remaining salt by subsequent affusion of water, left three grains of *siliceous earth* behind, in the form of sand.

o) The remainder of the alkaline solution (n), was subjected to digestion with boiling aqua regia. The earth, contrary to custom, swelled into a slimy matter, and the liquor acquired a greenish tinge. I filtered the solution previously diluted with water; mixed it with the preceding, which was likewise prepared with nitro-muriatic acid (m), and added prussiat of pot-ash. The greyish-green precipitate thus produced, when heated to redness, weighed no more than half a grain. The portion of *oxyded iron*, thus detected in the jargon under examination, may therefore be estimated at one fourth of a grain.

*Note.* Some phenomena which appeared on examining this precipitate, obtained by means of prussiated pot-ash, led me to suspect



suspect a slight trace of the presence of Nickel. However, since, on every subsequent examination of the jargon, no such indication any more occurred to me, I think the above appearance to have been merely accidental.

p) Carbonated vegetable alkali, being then added to the nitro-muriatic solution, precipitated of a white colour the remaining portion of earth, which it still contained. This earth, upon examination, was found to be of exactly the same nature with that obtained from the first solutions.

q) After the residual undissolved earth had been ignited, it weighed five grains. I consider this as the remainder of the rough jargon, which had eluded the attempts to decompose; it the farther analysis of which, from the minuteness of its quantity, could not be undertaken.

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C.

I now proceeded to the closer examination of that part of the jargon, which was found to be soluble in acids.

a) According to the established rule, the above sulphuric solution (B. i) should be supposed to contain either magnesian, or aluminous earth, or a mixture of both. However, the taste gave not the least indication of either. On the contrary, it was hardly distinguishable from that of pure sulphuric acid, and but gently astringent. In endeavouring to crystallize it, I expelled a part by evaporation, combined the remainder with a proportionate quantity of pot-ash, and waited to see whether aluminous crystals would form. It is true, on farther evaporation, there separated a crystalline milk-white crust; which, however, could not be taken

for alum, but only sulphat of pot-ash, together with which a portion of the dissolved earth was deposited.

b) To carry the experiment farther, I dissolved the above-mentioned saline sediment in water; and in order to collect the whole quantity of the jargonic earth, I likewise dissolved that portion of it, which I had recovered from the muriatic solution (B. g), by means of ammoniac, as well as that which I had precipitated by vegetable alkali, from the nitro-muriatic solution (B. p). Both these last I dissolved in dilute sulphuric acid, and added the solutions to the preceding.

c) I now once more directed my attention to the metallic ingredient in the jargon, to detect which, I could employ only the prussiat of pot-ash. The first portion which was added, produced in the colourless solution a dirty olive-green; but subsequent additions, made by degrees, tinged the mixture of a deep-blue. After the blue precipitate had subsided, it was collected and dried. It weighed three grains; of which the proportion of *iron* may be estimated at a fourth part, that is, three fourths of a grain.

d) Upon this I saturated the whole of the sulphuric solution with crystallized alkali, prepared from tartar; on which the earth, which separated, imparted to the mixture an uniform, milky appearance. The earth thus deposited and washed, was subjected, while yet moist, to the following experiments.

e) In diluted and gently warmed sulphuric acid it dissolved without any effervescence, though it had been precipitated by carbonated alkali; which shews, that this earth has no affinity with carbonic acid. The sulphuric acid took up a large quantity of it. I continued adding this earth to the  
the



the acid, until the last portion gave the solution an opaline appearance; but this again disappeared on the addition of a slight quantity of sulphuric acid, so that the solution then became clear. After cooling, it congealed into a milk-white, pulpy substance. For this reason I again added a little sulphuric acid, which, assisted by a low heat, rendered the solution again limpid, so that it no longer coagulated in the cold. I then left it standing at rest in a low temperature, and after some days I found the greatest part of it shot into small, detached, and clear crystalline groups, in radii of a flattened quadrilateral columnar form, diverging from a common centre, and terminating in sharp points. Their taste was but little sour, and left on the tongue a slight astringency. When thrown into water, they soon and easily dissolved, at the same time that they lost their limpidity and became turbid. The remainder of the solution still afforded some crystals of a fine granular form; and the last portion thickened into an irregularly shaped mass.

f) Distilled vinegar, concentrated to a fourth part of its bulk by freezing, dissolved the earth with equal readiness, receiving from it the peculiar taste already mentioned. This acetic solution dried by heat into a pulverulent residue, deliquescent in the air.

g) I likewise boiled a portion of the jargonic earth with a lye of concentrated and caustic lixivium of pot-ash, previously heated to boiling. The earth merely subsided in it in a loose, flocculent form, without being dissolved.

b) It is, then, manifest, from the foregoing experiments, that the *Jargonia*, or jargonic earth, is entirely different from the aluminous. That it is equally distinct from the magnesian earth, has already been proved by the total absence of all magnesian taste in the sulphuric solution,



tion, as well as by its incapability of absorbing carbonic acid. However, that no circumstance might be left unexplored in this examination, I re-dissolved in sulphuric acid the portion that yet remained; and having saturated with carbonat of lime the solution heated to boiling, I filtered the fluid from it after cooling. But neither the taste, nor any other re-agents, could discover the smallest sign of magnesia.

i) When this earth was tried with the blow-pipe upon charcoal, the phosphoric salt proved unable to dissolve any part of it, although its action was long continued; for the earth remained in the clear globule of that salt without any alteration. Nor was it found in any way attacked, when fused with soda in the small silver-spoon. However, it dissolved by degrees, completely, and without bubbling, in glass of borax; and the bead, thus produced, continued perfectly clear and colourless.

From the result of these experiments concerning the properties and relations of the earth extracted from the jargon, I think myself justified in considering it as a *new, distinct, simple earth*, before unknown; and at present I give it the name of *Zircon-earth* (*Terra Circonia\**), until it may, perhaps, be found in other species of stones, or possessed of other properties, that may give rise to a more appropriate denomination.

In the mean time, I wish that the above facts may excite that attention which I think they deserve: in order to induce one or more eminent chemical analysts to repeat

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\* In this country JARGONIA. Transl.



these researches, whereby the results of my own may be either confirmed or corrected.

The proportion of the ingredients, constituting the jargon, is yet left to be determined. But it is obvious, that, whenever new constituent parts are discovered, the nature of which is as yet entirely unknown, and which do not admit of being treated by the methods hitherto practised, the determination of their proportions cannot be brought to that high degree of accuracy, which may be expected when the Chemist pursues a beaten path, and cannot want a chemical knowledge of the constituent parts which he meets with in the subject under his examination.

Hence, as from the *two hundred* grains of the jargon, subjected to this analysis, I obtained

|                                       |       |               |   |         |
|---------------------------------------|-------|---------------|---|---------|
| <i>Silex</i> . . . B. l)              | . . . | 58 grs.       | } | 61 grs. |
| n)                                    | . . . | 3             |   |         |
| <i>Oxyd of iron</i> . o)              | . . . | $\frac{1}{4}$ | } | 1       |
| C. c)                                 | . . . | $\frac{3}{4}$ |   |         |
| Remainder of undecomposed             |       |               |   |         |
| <i>jargon</i> . B. q)                 | . . . | . . .         |   | 5       |
| The quantity of this newly discovered |       |               |   |         |
| JARGONIA may be estimated at 133      |       |               |   |         |

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200

And supposing that these remaining undecomposed five grains contain the same proportion of constituent parts, we may estimate the ingredients in 100 parts of the jargon to be the following:

*Silex*

|                               |       |
|-------------------------------|-------|
| <i>Silex</i> . . . . .        | 31,50 |
| <i>Oxyd of iron</i> . . . . . | 0,50  |
| <i>Jargonia</i> . . . . .     | 68    |

---

 100

## SECOND SECTION.

SINCE repeated experience has shewn me the powerful influence which the caustic alkali, when employed in the liquid state, exerts in promoting a more complete decomposition of the harder species of stones, I could not avoid subjecting the jargon likewise to this method of treatment. But to avoid superfluous prolixity in this essay, I shall confine the circumstantial detail of these new experiments to that analytical process only, which I have found the most convenient.

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### A.

a) *One hundred* grains of selected jargons, previously comminuted in the steel-mortar, were ground with water to a most subtle powder, in the triturating dish-made of flint. When dried and ignited, they were found to have acquired *one half grain* of additional weight.

b) The powder of these stones was next strongly digested in a menstruum, compounded of  $1\frac{1}{2}$  ounce of muriatic acid, and half an ounce of the nitric. Caustic ammoniac, poured into the filtered bright-yellow fluid, produced a yellowish-white precipitation, weighing two grains after drying. The iron, which this precipitate contained, was re-dissolved in moderately strong muriatic acid, poured upon it in the cold;



cold; another part of it remained undissolved, and was separated by filtration. The ferruginous contents of this last yellowish solution were again thrown down, in the form of brown, flocculent particles, by means of caustic ammoniac; after which they were collected and ignited upon charcoal. The precipitate appeared then in black, shining grains, which obeyed the magnet, and weighed  $\frac{1}{2}$  grain.

That portion which would not again dissolve, and which still preserved its former yellowish-white hue, I likewise heated to redness, upon a piece of charcoal. By this management it acquired a faint, dark-brown colour at the first moment of ignition:—a phenomenon which does not usually take place, except in the white oxyd of manganese. This portion weighed  $\frac{3}{4}$  of a grain.

c) Upon the pulverized jargon, after treatment with acids, and adding the above-mentioned residuum of  $\frac{3}{4}$  of a grain (b), I poured two ounces and a half of a caustic lye, in which the saline part made half the weight. The whole was then inspissated in a silver-crucible to dryness, and moderately ignited for two hours; by which treatment the mass preserved a pap-like consistence. When refrigerated, I softened the indurated, grey-white mass with water. The powder of the stone, thus separated from the alkaline lye, when washed and dried in a low-heat, now resembled elutriated chalk, and weighed 128 grains.

d) I then saturated the clear alkaline lixivium (c) with sulphuric acid. By this it was not rendered turbid; but only after it had been evaporated to dryness, and the saline mass again softened with water, there appeared *siliceous earth*, amounting to three grains after ignition.

e) The



e) The above jargonic powder (c), being now prepared for solution in acids, I first affused upon it eight times its weight of water; and upon this mixture, which had assumed a milky appearance, I poured a sufficient quantity of dilute sulphuric acid. In this menstruum, assisted by heat, the whole of the powder (a few impurities excepted), dissolved into a limpid, colourless liquor. After cooling, there settled around the sides and bottom of the glass-vessel an irregular crust, consisting of white crystalline grains; which again dissolved upon affusing more water of a warm temperature. This being done, the colourless solution was evaporated with a low heat. At the beginning of the process it remained clear, but afterwards it coagulated into an uniform, pellucid jelly.

f) When this gelatinous coagulum had again been digested with a large quantity of water, it dissolved into the form of transparent, viscid grains; which, collected on the filter, and desiccated, resembled glassy sand. These being exposed to a red heat, with four parts of mild vegetable alkali, and the mass re-dissolved in water, left behind 3 grains of earth. Sulphuric acid precipitated the *siliceous earth*, which was dissolved in the alkaline solution, in its usual slimy form. Its quantity amounted, after ignition, to 24 grains.

g) After those three grains of earth (f), had been re-dissolved in sulphuric acid, and, along with their solvent, added to the remainder of the foregoing solution, I precipitated the *jargonic earth* contained in that fluid, by means of a boiling lye of carbonated pot-ash. The precipitated earth,edulcorated and dried in the air, was of a moderately loose cohesion, of a white colour, a little inclining to that of flesh, and weighed 122 grains. One fourth part of it,



when ignited, amounted to  $17\frac{1}{2}$  grains; which gives 69 for the whole.

Therefore, the constituent parts of the *jargons*, analysed, are, in one hundred,

|                                 |      |                 |               |
|---------------------------------|------|-----------------|---------------|
| <i>Jargonic earth</i> . . . . . | g)   | . . . . .       | 69,           |
| <i>Silex</i> . . . . .          | d)   | . . . . .       | 3             |
|                                 | f)   | . . . . .       | 24            |
| <hr/>                           |      |                 |               |
|                                 |      |                 | 27            |
| From which subtracted a)        | .    | .               | $\frac{1}{2}$ |
| <hr/>                           |      |                 |               |
|                                 |      | $26\frac{1}{2}$ | . 26,50       |
| <i>Oxyd of iron</i> . . . . .   | b)   | . . . . .       | 0,50          |
| <hr/>                           |      |                 |               |
|                                 |      |                 | 96            |
|                                 | Lofs | .               | 4             |
| <hr/>                           |      |                 |               |
|                                 |      |                 | 100           |

B.

I shall farther mention some of my other analytical processes, repeated on that subject under circumstances somewhat diversified, and also the observations which have occurred to me concerning the chemical habitudes, or relations of *jargonic earth*.

a) Both the accurate discovery of the proportion of the siliceous earth, and its thorough separation from the earth of *jargon*, are rendered highly difficult by their intimate union, as well as by their reciprocal solution of each other. This end I have attained, in the surest way, by the method just now

now described : and for this reason I recommend this as the best among several that I have attempted. However, there seems to obtain some little difference in the proportion of the siliceous earth, depending on the nature of the several varieties of the jargon; which is likewise made probable by the small differences in the specific weight of various specimens of this stone.

b) If, upon the mass obtained by softening the jargon with water, after its ignition with caustic alkali, muriatic or sulphuric acid be immediately poured, to a slight degree of super-saturation, the whole is directly dissolved, clearly, and without residue. The earth precipitated by means of alkali from this solution, hardens, during desiccation in warmth, into transparent, vitreous, heavy, solid, and brittle lumps; which, in the moment they are removed from the heat, fly into small pieces, with vehemence and noise; some of which, if not inclosed in paper, are often thrown to a great distance. The higher the temperature in which the earth has been dried, the greater is the residue left behind undissolved, when again conveyed into acid menstrua, for solution.

c) It does not seem that the boiling of rough, pulverized jargon, in acids, is fully competent to extract completely their proportion of iron. If, therefore, the prepared earth of jargon be again dissolved in an acid, and combined with prussiat of pot-ash, the ferruginous remainder will appear in the form of a precipitate, sometimes of a Prussian-blue; at others, of a bright mountain-blue. But this precipitate is unable to indicate the true quantity of iron which it exhibits; for it consists not only of a small portion of oxyded iron, but also of a much greater part of jargonic earth, thrown down along with it, which afterwards resists a farther separation. It is, from the presence of this earth,  
united



united with the precipitated iron, that the above precipitate acquires a pale, reddish colour after ignition, and is hardly attracted by the magnet.

Consequently, not so much with the view of ascertaining the proportion of the constituent parts, as to produce the *jargonia* absolutely free from iron, it is adviseable to re-dissolve the earth first obtained, in an acid, and to separate that small remainder of iron by prussiated alkali. The iron being thus got rid of, the earth of circon, now perfectly pure, should be at last precipitated by means of an alkali, in a heat of ebullition.

d) To obtain the circon-earth in a state of easy solution in acids, it is necessary that, after precipitation and washing, it should be dried in a gentle heat only. Strongly ignited earth of jargon will not dissolve in acids, unless again previously prepared for that process by igniting it along with caustic alkali.

e) When the *jargonia* is to be precipitated from acid solutions, by means of carbonated pot-ash, the point of saturation should not be exceeded; since, otherwise, in proportion to the excess of alkali added, it will, either in part or wholly, be re-dissolved in the fluid, and can only then be made to re-appear by adding fresh acid to the superfluous alkali. However, this earth is not re-dissolved, if the precipitation is performed by caustic vegetable alkali, though the fluid should happen to be super-saturated with the salt.

f) Of all the acid solutions of jargonic earth, that which is prepared with muriatic acid has the greatest tendency to crystallize. If committed to spontaneous evaporation, the *muriat of jargonia* shoots into very slender, acicular

lar crystals, radiated in a diverging direction, which continue dry on exposure to air.

g) The jargonite is not at all disposed to vitrification; which is proved by the following experiment. A glass frit, composed of 60 grains of jargonite, and 40 grains of mild alkali prepared from tartar, was exposed, in a crucible made of clay, to an intense and long continued fire. But by this process not only was no union of these two substances effected, but they even entirely separated. The alkali fixed itself on the sides of the vessel in indurated grains; and in the middle the jargonitic earth lay by itself, in the form of a coarse, harsh, and loosely conglomerated powder, of a yellowish-white colour.



## XIII.

## CHEMICAL EXAMINATION

OF

## HYACINTH.

ON giving the first information of the new simple earth discovered in the Jargon of Ceylon, I declared, at the same time, my earnest desire of seeing this discovery farther pursued, and confirmed by probatory researches of able chemists. That wish, however, remained unfulfilled, with the exception of some few experiments made by *Gmelin*. It is probable that the few opportunities, which have hitherto occurred of obtaining jargon pebbles in a sufficient quantity, have prevented chemists from instituting a particular inquiry into their nature. They will, therefore, it is hoped, find pleasure in hearing, that the same earth is likewise contained in another gem, the *Hyacinth*, which may be easily obtained, and in sufficient quantity. This information will, perhaps, cause surprize, since the analysis of the *Hyacinth*, published by *Torb. Bergman*, appears to have been long since confirmed by its general reception. According to this, the *Hyacinth* is supposed to consist of,

196 XIII. *Examination of Hyacinth.*

|    |       |                      |
|----|-------|----------------------|
| 40 | . . . | <i>Argil,</i>        |
| 25 | . . . | <i>Silex,</i>        |
| 20 | . . . | <i>Lime, and</i>     |
| 13 | . . . | <i>Oxyd of iron.</i> |

Therefore, to obviate all doubts that may arise concerning the correctness of my present analysis, I declare before hand, that it is not merely the result of one single and superficial decomposition of the Hyacinth, but of several analyses of that gem, performed at different intervals of time, and in every respect complete.

The native country of the Hyacinth, which was the subject of the following experiments, is *Ceylon*.—Whether those species of stones, which in European countries, in *Bohemia, Italy, and France*, for instance, are indicated by this denomination, are true Hyacinths, I have not, as yet, been able to convince myself by any satisfactory proof.

I have found the specific gravity of the genuine Hyacinth for the most part to agree with that of the Jargon; that is, according to its varieties, from 4,545 to 4,620.

The detail of the experiments, which, with some variations, I repeated with the Hyacinth, may be the less circumstantial, since, in essential points, the same holds good with respect to this gem, as what I have stated in the second section of the preceding essay to belong to the Jargon, its analysis and its constituent parts.

a) *One hundred grains* of Hyacinth received, by levigation in the flint-mortar, an increase of weight of  $\frac{1}{2}$  grain; which shews that its hardness is not materially different from that of the jargon

b) This



b) This pulverized hyacinth, digested with two ounces of nitro-muriatic acid, yielded, upon saturating the solution with pot-ash, a light-brown precipitate, of  $3\frac{1}{2}$  grains, when dried. Ammoniac, added to it, dissolved nothing; and it remained colourless. After the precipitate had been again separated from the volatile alkali, I put it into muriatic acid, which dissolved its ferruginous contents, leaving a white earth behind, which, when ignited, weighed  $1\frac{1}{2}$  grain. The portion of iron, precipitated by caustic ammoniac from the muriatic solution, weighed  $\frac{1}{2}$  grain, when ignited, and became black and resplendent. I fused it with a neutral phosphat, upon charcoal, in order to find whether it contained manganese; but no trace of it was perceptible.

c) The above  $1\frac{1}{2}$  grains of earth (b) were now added again to the hyacinth, after treatment with acids. The stone was then subjected to red-heat, with six times its quantity of caustic alkali, in the manner explained in the essay on the jargon of Ceylon; the ignited mass was again liquefied with water; and the earth remaining after this process weighed 123 grains, when collected,edulcorated, and dried.

d) The alkaline lixivium was then saturated with muriatic acid, and evaporated. At first it continued clear; but towards the end *siliceous earth* separated, the quantity of which, after ignition, amounted to 6 grains.

e) Upon those 123 grains, previously well washed with water, I poured a sufficient quantity of muriatic acid; which, with the assistance of heat, dissolved nearly the whole, a trifling residue excepted. This muriatic solution, evaporated in a moderate heat to a sixth or eighth part, lost its fluidity, and formed a limpid gelatinous coagulum.

It was then covered with water, and exposed, with repeated agitation, to a digesting heat. By this management, the *siliceous earth* separated in slimy, intumesced grains, and weighed, after ignition,  $23\frac{1}{2}$  grains.

f) The solution, thus freed from its *silex*, was now saturated with a boiling lye of mild alkali; and the precipitate was washed and dried in the air. This last weighed 114 grains, proving, upon every trial, to be *jargonie earth*. A fourth part of it, heated to redness, weighed  $16\frac{1}{2}$  grains; which make the whole amount to 66 grains.

g) The above 6 grains (d), with the  $23\frac{1}{2}$  grains (e) in the whole  $29\frac{1}{2}$  grains of *siliceous earth*, were ignited with a quadruple weight of vegetable alkali. When this mass had been again softened with water, it left a residue, which I extracted by muriatic acid. From this muriatic solution, also, when saturated with pot-ash, *jargonie earth* fell down, weighing 4 grains after ignition. Hence, subtracting these, the quantity of *siliceous earth* is reduced to  $25\frac{1}{2}$  grains.

One hundred parts of *hyacinth*, therefore, have given

|                     |          |                     |      |        |
|---------------------|----------|---------------------|------|--------|
| <i>Jargonia</i>     | . . f)   | . . 66              | }    | . . 70 |
|                     | g)       | . . 4               |      |        |
| <i>Silix</i>        | . . . g) | . . $25\frac{1}{2}$ |      |        |
| Subtract            | . . a)   | . . $\frac{1}{2}$   |      |        |
|                     |          | <hr/>               |      |        |
|                     |          | 25                  | . .  | 25     |
| <i>Oxyd of iron</i> | . . b)   | . . . . .           |      | 0,50   |
|                     |          |                     |      | <hr/>  |
|                     |          |                     |      | 95,50  |
|                     |          |                     | Lofs | 4,50   |
|                     |          |                     |      | <hr/>  |
|                     |          |                     |      | 100    |

What



### XIII. *Examination of Hyacinth.* 199

What I have already mentioned, when treating of the jargon of Ceylon, both with respect to the variation in the proportion of the flux, and the small quantity of iron still remaining, which may be separated by means of Prussian alkali, applies likewise to the hyacinth.

Hence, the *jargon* of Ceylon, and the *hyacinth*, should, in future, be ranked in the series of natural bodies as *two species*; or, if it be preferred, as *two genera*, under *one peculiar and distinct order of stones*. But which of these two is entitled to preference, in giving its name to the genus?—The jargon has, indeed, already obtained that distinction; but ought it not to, be transferred to the hyacinth, being a gem much older, longer known, and more esteemed?—If so, the denomination *hyacinth-earth* should then be adopted, and substituted to that of *circonia*, or *jargonia*.

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## XIV.

## CHEMICAL EXAMINATION

OF THE SUPPOSED

*HUNGARIAN RED SHÖRL.*

THE fossil, found at *Boinik*\*, in Hungary, and called *red Shörl*, is there dug up from a bed of quartz, stratified with shistose mica. Its colour is a pale brownish-red. Its figure is a column strongly furrowed, or channelled, lengthways, which, in my specimens, exhibits a rectangular parallelopipedon. The larger specimens which I possess are  $\frac{1}{2}$  inch thick; but these shörls are commonly thinner, and form only needle-shaped crystals, the external surfaces of which are striated, and, as well as those of the fragments, strongly shining. Their cross fracture is foliated; the longitudinal fracture of a medium between the foliated and uneven, and in some parts of the minute conchoidal. The splinters of this fossil, and thin edges, are transparent, like the light-red silver-ore, which, in general, it very much

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\* *Born* mentions *Rboniz* as the place where it is found. See his *Catalogue Meth. et Rais. de la Collect. d. Fossil.* Tom. i. p. 168.



resembles when in fragments. It breaks into small acute-angular pieces, which, however, shew a very great hardness on trituration; and the colour of the powder is between the orange and brick-red. Its specific gravity I have found to be 4,180.

It was undoubtedly the oblong form, together with the striated, fluted surface of its crystals, which occasioned this fossil to be classed under the tribe of shörl: whereas other mineralogists think themselves entitled, from its colour and fracture, to reckon it a garnet.

But it will be made evident by the results of the following analysis, that this mineral body belongs neither to the one nor to the other of those species of stones, nor at all to the class comprising the genera of earths and stones. On the contrary, it will appear that it consists of a *peculiar, distinct, metallic substance*.\*.

A.

a) I exposed a piece of this mineral, in a *crucible made of clay*, to the heat of the porcelain furnace. By this it suffered no change as to figure and lustre; but the colour passed into a deep brown-red.

b) Another specimen, that was subjected to a porcelain heat in a *charcoal-crucible*, burst into angular grains; while

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\* For the quantity of this rather scarce fossil, requisite to this analysis, I am indebted to the kindness of Count Würben, of Vienna.

202 XIV. *Chemical Examination of the*

its colour changed to a faint light-brown, and scarcely any of its original lustre remained.

c) When fused with an alkaline phosphat, upon charcoal, before the blow-pipe, no solution ensues. The globule acquires a pale reddish-grey, and turns opaque. A gentle pressure makes it fall asunder, in the form of sand.

d) Melted borat of soda (borax) dissolves it, uniting with it to a clear vitreous bead of an hyacinthine red.

e) If the powder of this fossil be fused in the silver spoon with *soda*, it gradually dissolves, and the globule becomes untransparent, and of a reddish white colour, after cooling.

B.

In order to examine the agency of acids on this mineral, when finely pulverized, I inserted several portions of it in four separate phials, and poured upon one *sulphuric*, upon the other *nitric*, upon the third *muriatic*, and upon the last *nitro-muriatic* acid; subjecting them all to long digestion in a strong heat. No action ensued in either; for the fossil was again taken out of each acid without any alteration.

C.

Having blended *one hundred grains* of the fossil, finely levigated with four times its weight of caustic pot-ash, I exposed it to a red-heat for one hour. When removed from the fire, I softened it by water, super-saturated with *muriatic* acid, and subjected it to digestion. There seemed

I

but



but little of it dissolved, and the undissolved part lay at the bottom of the vessel, as a white, tenacious, and heavy earth. When the mixture was thrown upon the filter, in order to separate the fluid, it passed through the pores of the paper in the form of milk. For this reason, I put the whole again together into one mass, diluting it with a greater quantity of water; and the earth having subsided after 24 hours, the water was decanted, and the sediment dried in a warm temperature. By this management it again acquired a reddish colour.

This seemed to indicate that the cohesion of this shörl was not yet perfectly loosened. I therefore ignited it once more with 200 grains of the caustic salt, and again digested, with muriatic acid, the mass previously softened. Even in this case the mixture resembled milk, and continued several days in this state, without becoming clear. I diluted it then with more water, and made it boil: upon which the earth separated in detached, flocculent particles, which then admitted of being collected on the filter. But they adhered to it very firmly and clammily; which, upon exsiccation, rendered its separation difficult.

I instituted several preliminary experiments with that portion which could be collected; by which I learnt, that, in this instance, I was engaged with a peculiar *metallic oxyd*.

#### D.

I repeated the decomposition of the fossil with such a variation of the process, as to avoid the difficulty in separating and collecting the precipitate, which took place in the preceding attempts.

Two hundred grains of the fossil, finely pulverized, and mingled with five times their quantity of carbonated alkali, were ignited in a porcelain-pot. The mixture entered into a thin fusion; but when poured out, it coagulated to a greyish-white, dense mass of acicular crystals, at the upper surface, and of a fibrous fracture. This I triturated and liquefied in boiling water. A white precipitate soon subsided, from which the supernatant liquor was filtered off, and saturated with muriatic acid. By this management, a white, slimy earth fell down, that weighed eight grains after drying, and consisted of a mixture of argillaceous and siliceous earths.

The residuum, washed, and desiccated in a gentle heat, appeared as a white loose earth, and weighed 328 grains.

## E.

This white earth was subjected to a number of experiments; the results of which were, as follows.

1. *Its relations to acids.*

a) It soon dissolved in *dilute sulphuric acid*, and afforded a clear solution, which, when exposed to the air, evaporated, leaving a white, turbid, paste-like substance behind it.

b) *Nitric acid* likewise formed with it a limpid solution. By spontaneous evaporation, this acquired an oily consistence, and deposited minute transparent crystals, the primitive figure of which was an oblong rhomb, and seemed to change into an hexahedral plate, or table, by the truncation of its two opposite acute angular ends.



c) When the solution of this earth in *muratic acid* was left to evaporate of itself, it thickened to a bright-yellow, clear, gelatinous substance, beneath which there shot a quantity of very small, clear, crystalline grains, of a cubical form.

In these acid solutions there remained between five and six parts of *siliceous earth* in the hundred. However, a quantity of *siliceous earth*, to appearance still more considerable, was yet left behind, in combination with the white earth, and entered with it into the solutions. It is by this circumstance that these solutions are reduced to a gelatinous coagulum, and that a more regular crystallization is impeded.

2. *Relations of these solutions to the precipitating media.*

a) *Carbonat of pot-ash* precipitates the dissolved earth in a white, light, flocculent form.

b) *Caustic ammoniac* produces the same effect.

c) *Prussiat of pot-ash* affords a large precipitate, mixed of grass-green and brown.

d) *Tincture of galls*, or *gallic acid*, throws down a brown-red precipitate, of very considerable bulk. If the solution has not been previously diluted with much water, it congeals like blood. Alkalis separate nothing from the decanted fluid. The precipitate, when collected, washed, and dried, has the appearance of *Kermes mineral* (red sulphurated oxyd of antimony). When I exposed 15 grains of this powder to a weak heat, upon coals, in a small crucible, it immediately glimmered, and turned white. After this degree of ignition, it was found to weigh 6 grains.

e) When

e) When combined with *acid of arsenic*, a white precipitate ensues.

f) The same is occasioned by *phosphoric acid*.

g) *Acid of tartar* produces a white precipitate, but which soon entirely re-dissolves.

h) The same takes place upon the addition of *oxalic acid*.

i) A small *stick of tin* was immersed in a phial, full of a muriatic solution of the fossil, and provided with a stopper. After some minutes a faint rose-colour shewed itself around the stick of *tin*, passing, at last, into a beautiful amethystine red.

k) Another phial, capable of being closed with a stopper, was filled with this muriatic solution, but diluted with six times the quantity of water; and into this I put a small stick of zinc. The solution at first changed to a violet, but afterwards to a deep indigo-blue. When placed in a warm temperature, in an uncovered dish, the solution gradually lost its colour, and deposited a white, bulky precipitate; which, when separated by filtration, and again dissolved in muriatic acid, retained the same properties as the earth did before the solution.

l) But the muriatic solution, when combined with *Hahneman's acidulous liquor, impregnated with sulphureous gas*\*, remained unaltered.

m) However, *Beguin's sulphuret of ammoniac*, added to that mixture, gave it a dirty, green colour, and produced a bluish-green precipitate. If the white earth, in the dry

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\* Hahneman's *Wine Proof*. See *Gren's Principles of Chemistry*, vol. ii. page 253. *note*.—Transl.



*state*, be covered with this fluid, it is immediately tinged of a brownish-green.

3. *Habitudes of the above-mentioned earth in the dry way.*

a) *Fifty grains* of the white earth, mentioned above, when ignited in a crucible, were afterwards found to weigh 38 grains. As long as it continued warm, it exhibited the yellow colour of sulphur; which, however, disappeared upon cooling. This earth, after ignition, is no longer acted on by acid menstrua.

b) But if the earth be heated to redness upon charcoal, it first becomes reddish, and then of a slate-blue. By this treatment it also fuses into an ill-shaped globule, which, after refrigeration, presents a finely radiated surface. However, this melting is effected, perhaps, only by a small portion of alkali, which still adheres to the earth.

c) The same earth, when fused upon charcoal, with a neutral phosphat and *borax*, or with *soda*, in the small spoon, yields the same results as does the rough fossil, when treated with these fluxes. (A. c. d. e).

d). This white earth, also, mixed and conveyed with a proper *enamel-flux*, upon porcelain, and baked, produced a pure straw-yellow colour, of a good body. This colour was likewise obtained by the raw mineral.

e) At last I attempted to reduce it to the reguline state. For this purpose I blended 60 grains of the white earth, ignited, with 30 grains of pulverized *colophony* (the residue after the distillation of the etherial oil from turpentine), and caused this last to burn away by means of a gentle fire. No sooner had the flame ceased, than the earth appeared

peared again as white as before. It was next divided into two parts. The one half of it was mingled with 20 grains of pulverized white glass and 10 grains of calcined borax, and inclosed together in a crucible made of charcoal. The other half was introduced—alone—into the cavity of the charcoal-crucible, covered only with a mixture of glass and borax. Both crucibles, well secured, were then put into the porcelain-furnace; and both afforded the same product; which consisted of an irregularly fused slag, or scoria, brownish at top, light-blueish-green below, and of a finely porous fracture, with some detached large air-holes, the interior sides of which seemed to be confusedly striated.

This fossil, therefore, belongs to those *metallic substances* which appear to be incapable of being exhibited in the state of a fused metallic bead.

## F.

The sum of these results furnishes several arguments, upon the strength of which I do not scruple to consider the *red spörl*, as it has been hitherto called, of *Boinik in Hungary*, as a natural *metallic oxyd*. The phenomena, upon which I ground my conclusion, are: That the white earth, subjected to ignition, becomes yellow, reddish, and, in contact with charcoal, blueish; that it produces a yellow enamel colour; that it is precipitated from its solutions in acids, by Prussian alkali, gallic acid, and alkaline sulphuret; that, when treated in the humid way with tin and zinc, it is recovered in dark flakes, the solution then acquiring a red and blue colour; and, lastly, that it shews a very strong tendency to combine with oxygen. It is on account of this last property, that the crude fossil, as being fully saturated



rated with that acidifying principle, is insoluble in acids, and is rendered capable of solution only when, by ignition with an alkali, it is deprived of a part of its oxygen. For this reason, likewise, when I ignited the rough fossil, in a subsequent analytical experiment, with only two parts of vegetable alkali, the earth obtained did not prove so white and loose as that fused with five or six parts. It also dissolved but imperfectly, in muriatic acid, and not at all in the sulphuric and nitric.

To these facts must be added the phenomenon, that the muriatic solution of that substance became changed into a blue tincture by zinc; but when decanted, and exposed to open air, in a warm place, it again lost its colour, by imbibing oxygen, and deposited a white earth.

Another phenomenon, probably the consequence of super-saturation with oxygen, took place when I endeavoured to promote the crystallization of a complete muriatic solution, by evaporating it in a sand-bath. This was, that the liquor, which had before been perfectly clear, acquired a turbidness and resemblance to milk, by the heat: nor could it any more be rendered a limpid solution by the fresh addition of acid.

It is sufficiently shewn, by several of its properties, that this metallic substance does not belong to any of those at present known, but rather deserves to be reputed a new, peculiar genus of metals. Among these, the copious *brown-red precipitate*, produced by the gallic acid, furnishes an easy test and specific means of distinguishing it from other metals.

We are yet to give this new metallic substance an appropriate name.

P

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Whenever no name can be found for a new fossil which indicates its peculiar and characteristic properties (in which situation I find myself at present), I think it best to choose such a denomination as means nothing of itself, and thus can give no rise to any erroneous ideas. In consequence of this, as I did in the case of the Uranium, I shall borrow the name for this metallic substance from mythology, and in particular from the *Titans*, the first sons of the earth. I therefore call this new metallic genus TITANIUM\*; of which this *Titanium*, mineralized by oxygen, or oxyd of *Titanium*, is, indeed the *first*, but perhaps not the only species, as is made probable by the following essay.

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\* The metal called *Menachanite*, by Kirwan, Mineralogy, vol. II. part iv. chap. 21, is the same, or analogous to Klaproth's *Titanium*. See *Gren's Principles of Modern Chemistry*, 1800. Lond. 3vo. vol. ii. page 425.—Transl.

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## XV.

## CHEMICAL EXAMINATION

OF

*A NEW FOSSIL, from the Diöciēt of Passau.*

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AMONG the various and hitherto unknown crystallizations of some fossils, which professor *Hunger* has discovered in the bishopric of Passau, and whose external characters he has described\*, there is one particularly remarkable, as even its constituent parts are not yet known.

The crystals of that fossil are small quadrangular rhombic columns, of a reddish, greyish, and blackish-brown colour. Their size varies from  $\frac{1}{16}$  to  $\frac{1}{4}$  of an inch. Their lateral facets are joined alternately, under angles from 135 to 45 degrees. Both their ends form very sharp angles; and the inclining sides issue from the obtuse lateral edge. Their surface is smooth and resplendent. Their cross-fracture is dim, but their longitudinal fracture exhibits a middling lustre. The smallest crystals of that mineral, and sometimes its edges, are transparent; but it is often totally

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\* *Beobachtungen und Entdeckungen aus der Naturkunde.* 5ter. Band, 2tes St. Berlin, 1794.

opaque. Though its crystals are brittle, and easily friable, yet they shew a considerable hardness when grinding, and then afford a whitish-grey powder.

It is met with in several places in the neighbourhood of *Passau*, and also, though seldom, in the *Innviertel*, in *Bavaria*. Those crystals almost always occur dispersed in a species of coarsely-grained stony matter, the predominant part of which consists of a greyish, or greenish-white felspar, mingled with hornblende, quartz, mica, semi-indurated steatites, of which sometimes all together are united with it; and, at other times, only one or two\*.

## A.

a) The specific gravity of this fossil is 3,510.

b) Its crystals, when ignited upon charcoal, before the blow-pipe, suffered no remarkable change, except that here and there very minute bubbles were produced on their surface.

c) Exposed in a *crucible made of clay*, to the most intense heat of the porcelain furnace, they likewise continued without farther alteration; but in the *charcoal crucible* they concreted into a scoria, half-fused, black, opaque, somewhat porous, and of a moderate lustre.

d) On being treated in the humid way with muriatic acid, and repeatedly digested with it, one third part of their

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\* Professor *Hunger* had the kindness to send me some of his crystals, which had been collected with great trouble, in quantity sufficient for investigating the constituent parts of this mineral.



weight was dissolved. This solution had a straw-yellow colour; and the addition of caustic ammoniac, in excess, afforded a precipitate, whose appearance and consistence resembled paste made of starch; but which, when dried and ground, exhibited a loose, yellowish powder. The remaining fluid contained, also, some *calcareous earth*, which I precipitated from it by carbonat of soda.

What remained, after the extraction by means of the acid, I subjected to ignition, together with four times its weight of mild alkali, prepared from tartar. It was next saturated to excess, and digested with muriatic acid, and filtered. *Siliceous earth* was then left behind on the paper. Caustic ammoniac threw down from this solution a precipitate perfectly resembling the foregoing; to which, therefore, it was added.

The external appearance of this precipitate led me to suspect in it the presence of aluminous earth, impregnated with iron. However, it was not found to be so upon farther examination: for, after I had again dissolved it in muriatic acid, and once more precipitated it from this last solution, the caustic alkaline lye, with which the precipitate was digested afteredulcoration (while yet in a pulpy state), would dissolve only a very trifling portion of it.

I then fused, with glass of borax, a small portion of the precipitate, again washed and dried; and obtained a small topaz-yellow glass-globule. Another portion, fused with phosphoric salt, produced one of a pale amethystine colour.

Again; another small portion of it, which was dissolved in dilute sulphuric acid, shewed no sensible taste of alum, and dried to a whitish mass, without shooting into crystals.

The remainder of that precipitate I re-dissolved in muriatic acid, and treated the solution with the following tests, or re-agents.

*Prussian alkali* produced a dark-green precipitate.

*Gallic acid* afforded a precipitate of a lively brown-red colour, but passing into a pale yellow-red, as it cooled.

A little stick of zinc was immersed into that part of the solution which yet remained; and a subtle greenish-black slime was observed settling around it, at the same time that the solution itself assumed the colour of amethyst. The fluid again lost that colour after some days, and white, flocculent particles, mingled with the slime, fell down.

#### B.

Guided by these previous observations, I proceeded to the following new experiment.

a) *One hundred grains*, finely ground, were subjected, for one hour, to ignition, with a quadruple weight of caustic alkali. The mass, softened by water, yielded a weak grass-green solution; but this colour disappeared again, as soon as more water was added afresh. Upon digesting it with muriatic acid, added to excess, and subsequent filtration, *siliceous earth* was left behind, which, when ignited, amounted to 12 grains.

b) The dissolved part was next precipitated, by means of carbonated pot-ash. Upon the dried precipitate, I added a new portion of muriatic acid, and a notable smell of oxygenated muriatic acid gas was emitted. During the di-



digestion, there again separated some *siliceous earth*, the quantity of which, after ignition, amounted to 23 grains.

c) At this time, I combined the solution with caustic ammoniac. The yellowish-white precipitate, obtained thereby, weighed 62 grains, upon desiccation. One *fourth* part of it, heated to redness, was found to weigh  $8\frac{1}{4}$  grains; whence its whole quantity makes 33 grains.

d) To the remaining fluid, mild vegetable alkali has been added, at a boiling heat. It thereby yielded *calcareous earth*, to the amount of 33 grains, when ignited.

C.

Having, in this manner, discovered the proportion of the constituent parts, I next examined, a second time, the precipitate obtained (B. c.).

a) When ignited alone upon charcoal, it turned brownish-yellow, and, at last, blackish.

b) By fusing it with *borax*, a transparent globule of an hyacinthine colour was produced.

c) *Phosphoric salt* did not dissolve it, but only divided it minutely. If any trace of manganese had remained in this precipitate, it would have manifested itself by a faint amethyst-colour, with which it tinges phosphoric glass.

d) The portion dissolved in acids was thrown down by *tincture, or acid of galls*, of a lively, brown-red hue.

e) *Prussiat of pot-ash* afforded with it a green precipitate, inclining to brown, and thereby resembling sap-green. This, however, when dried, appeared again with its original green colour. The liquor, separated from it by filtration, was not altered by re-agents.

f) The addition of *sulphuret of ammoniac*, prepared after *Beguin's* manner, produced a flocculent precipitate, of a dark muddy-green.

g) *Phosphoric acid*, as well as

h) *The acid of arsenic*, produced a white precipitate.

i) Lastly, this precipitate, when combined with a proper quantity of enamel-flux (*glafs-paste*), and thus laid upon porcelain, and fused, gave to its surface a *yellow* colour, verging to brown.

Therefore, since these results not only indicate, in an unquestionable manner, the metallic nature of this constituent part, but, moreover, since its habitudes, upon the whole, very much correspond with those of the Titanium (the new metallic substance treated of in the last essay); and, finally, since the trifling varieties in the various phenomena seem to originate merely from accidental circumstances, I do not hesitate to reckon this constituent part as an *oxyd of Titanium*.

And, in order that this fossil itself may be distinguished by a particular name, as a *distinct species*, the denomination *Titanite*, derivated from the above new metallic substance, does not seem to be altogether improper. Its constituent parts have been found to exist in it in the following proportions:



XV. *Of the new Fossil from Passau.* 217

|                                    |       |           |            |
|------------------------------------|-------|-----------|------------|
| <i>Silex</i> . . .                 | B. a) | 12        | } . . . 35 |
| .                                  | b)    | 23        |            |
| <i>Lime</i> . . . . .              | d)    | . . . . . | 33         |
| <i>Oxyd of Titanium</i>            | c)    | . . . . . | 33         |
| <i>Manganese</i> , a slight trace. |       |           |            |

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101

Now, what place ought to be assigned, in the mineralogical system, to this new fossil? Since mineralogists are not yet agreed as to the principles, according to which the system of mineralogy should be arranged, those who direct their principal regard to the *specific* constituent part, will readily class the *Titanite* as a *second species* of the *Titanium genus*. Such, on the contrary, as insist more strictly on the predominant part, with regard to quantity, will, perhaps, decide for its insertion under the head *siliceous genus*.

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## XVI.

## EXAMINATION

OF THE SUPPOSED

## MOLYBDENOUS SILVER.

A FEW years ago a metallic fossil was met with at *Deutsch-Pilsen*, in the *Comitatus Hontensis*, in *Hungary*, which by *Born* has been introduced as a new species of silver-ores.—He gives the following description of it\*.

## ARGENT MOLYBDIQUE.

Silver combined with sulphurated Molybdena.

“ This combination or alloy of silver with sulphurated  
 “ molybdena has been till now unknown. It is no where  
 “ found, except at *Deutsch-Pilsen* in *Hungary*, where it  
 “ was met with in insulated kidney-form nodules (roggons),  
 “ from one to two inches in thickness, enveloped in a common  
 “ grey clay. These nodules separate in pretty large and  
 “ shining laminas, that admit of a new division into smaller  
 “ lamellas, perfectly resembling sulphurated molybdena, and  
 “ staining the paper with grey traces. By cupelling this  
 “ sulphurated molybdena, there are obtained 23 marcs of sil-  
 “ ver (184 oz.), from one centner.”

As, from the peculiar scarcity of this mineral, few chemists only may have opportunity of examining it, I undertook this task the more readily: and I found by these researches, that it contains neither silver, nor molybdena, and that it consists of bismuth, mineralized by sulphur\*.

\* See his *Catalogue de la Collection des Fossiles de Mlle de Raab*.  
 Tom. II. p. 419.



A.

a) If this ore be tried *per se* upon charcoal, with the assistance of the blow-pipe, it runs into a globule, as soon as it comes in contact with the point of the flame. That globule may be gradually blown off by means of the bellows, in which case it gives out a metallic vapour, which in part settles on the coal, of a yellow colour. But if borax, or a neutral phosphat, be added, it separates from the melting saline pearl, and leaves the latter colourless behind it.

2) *Twenty-five* docimastic pounds of this ore † subjected to cupellation under the muffle, with four times their weight of lead, left behind them a globule of silver, only visible by the microscope; but this, undoubtedly, must have been furnished by the lead.

B.

a) Upon *fifty* grains of the triturated ore I poured moderately strong nitric acid. It was immediately attacked and dissolved by it, with extrication of red vapours; and the residuum consisted of  $2\frac{1}{2}$  grains of sulphur.

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\* That I may not be suspected of having bestowed my labour not upon the genuine *argent molybdique* of *Born*, I here declare, that the specimen which I examined was a fragment of the very individual piece, of which *Born* has described the above external characters.

† About  $24\frac{1}{2}$  drachms *Troy-weight*. The German docimastic centner, or one drachm, is equal to 72 *French* grains of the former *poid de marc*, which correspond to 59,0677 *English* grains *Troy*.  
Transl.

b) I

b) I afterwards diluted the solution with a large quantity of water; upon which the mixture instantaneously assumed the appearance of milk, and deposited a fine, white, and heavy precipitate, consisting of pure *oxyd of bismuth*.

c) The fluid separated by filtration was mixed with muriatic acid. It continued at first perfectly clear, but gradually it was rendered somewhat milky; and at the bottom there collected a subtle, ponderous precipitate, the dazzling whiteness of which suffered not the least change by the day's light, and was likewise merely *oxyd of bismuth*. Had there existed in it any trace of muriatic silver, however small, it would have discovered itself by tarnishing the white colour of that precipitate, on exposure to the light of the day.

Consequently, *one hundred* parts of this ore contain:

|                |           |       |
|----------------|-----------|-------|
| <i>Bismuth</i> | . . . . . | 95    |
| <i>Sulphur</i> | . . . . . | 5     |
|                |           | <hr/> |
|                |           | 100   |

From this small proportion of sulphur, it seems that the bismuth is but imperfectly mineralized; hence that ore nearly approaches to native bismuth. And probably on this circumstance depend its whiter colour, and brighter lustre, which so much resembles that of silver recently polished; and by which it is distinguished, in external character, from the sulphurated bismuth of *Riddarhyttan*, in *Westmanland*, which is more of a lead-grey colour.



## XVII.

## EXAMINATION

OF THE

## NATIVE ALUMINOUS EARTH

FROM SCHEMNITZ.

IN the pit called *Stephani-Schacht*, at *Schemnitz*, in *Hungary*, an earth was lately dug up, which is there reckoned to be aluminous earth, naturally quite pure and free from filix. It is as white as snow, light, crumbling, very friable; it stains but moderately, and adheres to the tongue\*.

I put this earth to the trial in the following manner:

a) One hundred grains of it were exposed to a strong red heat for one hour in a covered crucible. After refrigeration, I observed in it a loss of weight of 42 grains; which, it is obvious, was only the weight of the particles of water driven out by the fire. No alteration was effected by this in the exterior appearance of the earth; except that the pieces were made a little rifted, and diminished in size.

b) Another hundred grains of this earth were gradually conveyed into dilute sulphuric acid. They dissolved in it without effervescence, yet accompanied by an observable disengagement of caloric. The solution proved perfectly limpid; but upon evaporation it formed a clear and transparent coagulum, the surface of which, after a few days, appeared to be covered with a quantity of solitary, pyramidal, crystalline shoots. The mass was next drenched

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\* A fuller description of it has been given by *Fichtel*, in his *Mineralogische Aufsätze*. Vienna, 1794. page 170.

222 XVII. *Of the Native Alumine from Schemnitz.*

and digested with an abundance of water; and then *siliceous earth* separated, weighing 14 grains, when collected by filtering, and ignited.

c) When the solution, thus freed from the *filex*, had been combined with the requisite portion of pot-ash, and crystallized, it afforded pure alum; from which the aluminous earth was afterwards precipitated by means of pot-ash, and purified in the manner frequently mentioned.

Hence the discovered constituent parts of this earthy fossil amount to:

|                                              |    |
|----------------------------------------------|----|
| Ignited Alumine . . . c) . . . . .           | 45 |
| Silex . . . . . b) . . . . .                 | 14 |
| Aqueous particles lost by ignition . . . . . | 42 |

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101

The chemical knowledge of this earth is chiefly remarkable on this account, that hitherto, with the exception of some gems, no other mineral substance has been known, which consists of alumine and *filex* in such proportions that the quantity of the first so far exceeds the second. Whereas in the species of clay, strictly so called, for instance in the porcelain clay, the alumine which they contain is usually but equal to a *fourth*, or at most a *third* part of the *filex*. Whence it follows, that in the above fossil, the two constituent parts of clay are to each other precisely in the inverse ratio of that, in which they commonly exist in clay.

From the above results it is likewise evident, that this earth is by no means *absolutely pure alumine*, as has been supposed. As the only instance of alumine of that degree of purity, therefore, we must still consider that earth which is found at *Glauchau*, near *Halle*, on the river *Saale*, in single kidney-form pieces; although its true origin yet remains a problem to be solved.

XVIII.



## XVIII.

## CHEMICAL RESEARCHES

INTO

*STRONTIANITE,*

COMPARED WITH

*WITHERITE*\*,

—

SEVERAL properties, which *Strontianite* has in common with those of *Witherite*, seemed to justify its being taken, when first discovered, for a species of the native carbonate of barytes. However, by the circumstance of paper, dipped in a nitric solution of strontianite and dried, burning with a red flame, I was induced to conjecture, that this fossil might, perhaps, be distinguished from witherite by other properties. This supposition was strongly supported by the result of the chemical examinations instituted by *Sulzer* upon this substance, as well as by the experiments which *Blumenbach* has made upon animals.

It was probably the difficulty of obtaining strontianite in sufficient quantity, that has prevented the repetition and confirmation of those experiments; in consequence of this, the present additional essay, tending to procure a more accurate knowledge of it, may be deemed not superfluous.

But in order the better to compare the properties and chemical relations or habitudes of strontianite compared

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\* *Chemische Annalen*, 1793. 2 B. page 189. and *ditto*, 1794. 1 B. page 99.

with

with those of witherite, I have thought it proper to place together the results of an examination into each.

Both these fossils belong to those products of nature, that have been discovered only within the last ten years.

a) The place at which the *strontianite* was found the first time is *Strontian*, in *Scotland*; where this fossil breaks in a vein of lead, together with ponderous spar (sulphat of barytes), in a mountain chiefly consisting of gneiss\*. It is found massive, in oblong coarsely fibrous pieces, accumulated in bundles. It is of a light green, a little transparent, shining, and moderately hard.

Its specific gravity I found to be 3,675.

According to the experiments which *Blumenbach* has made with regard to the effects of *strontianite* upon animal life, it was found to possess nothing of the deleterious properties of witherite; as the former was eaten by animals without injury.

b) The *witherite*, or native carbonat of barytes, is dug in the lead-mines at *Anglezark*, in *Lancashire*; where, together with the foliated sparry barytes, it forms the *gangue*, or earthy matter, serving as a matrix to the galena. The miners and inhabitants of that vicinity have been long ago acquainted with this mineral, denominated by them *Rats-stone*, as containing a poison fatal to animals. The reason, why the geognostic situation and the true native place of witherite (falsely stated to be *Alston-Moor*, in *Cumberland*)

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\* This mountain is said by others to be granitic; however, the stony matter adhering to my specimens of *strontianite* proves it rather to be gneiss.



continued for some time misunderstood, was the concealment practised by the miners of that place, who, from its weight, suspected it to contain some noble metal; and perhaps also to the base interestedness of the usurious dealers in fossils.

The colour of *witherite* is grey-white. It usually occurs in considerable masses, and only occasionally in six-sided prisms, terminated by hexahedral pyramids. Thin fragments of it transmit the light. Its longitudinal fracture is glossy, and feebly striated; but its cross-fracture is only glittering and uneven. Its hardness is but middling; and its specific gravity is 4,300, and therefore more considerable than that of *strontianite*.

A second place at present known, where native carbonate of barytes occurs, is the *Schlangenberg*, in *Siberia*. There it is met with of a grey-white colour, in the form of a stalactitical incrustation, resembling *chalcedony*.

### FIRST EXPERIMENT.

a) One hundred grains of *strontianite* in coarse fragments, and put into a porcelain-vessel, were ignited during the space of two hours in a wind-furnace. Their figure was not sensibly altered by this; but their bright-green colour, their lustre, and transparency, were destroyed. On weighing them, while yet hot, I observed a loss of weight of no more than half a grain; and this loss seems to be merely that of the moisture expelled.

This experiment I repeated with another 100 grains; but exposing them for five hours to a fire of such intensity, as to be capable of converting white marble into quick-lime, in but half that time. By this much stronger and more lasting

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red-heat, they lost  $6\frac{1}{2}$  grains of weight. Hence, subtracting the above half grain, which, on account of the previous ignition, may be deemed watery parts, it follows, that six grains of *carbonic acid* were thus driven out. This burnt strontianite gave a caustic taste. I triturated and boiled it with four ounces of water, which I separated again by filtration. The taste of this much resembled that of fresh and strong lime-water. Two ounces of it were put aside in a slightly covered glass. After a few minutes it was already covered with a white earthy pellicle; which continued to form anew for several days, as soon as the preceding had been broken by agitation, and thereby caused to fall down in thin lamellas. When no more was produced, I collected these lamellas; and they weighed seven grains after drying. Dissolved vegetable alkali was then added to a part of the water, which had been boiled with burnt strontianite. The mixture became milky, and deposited carbonated strontian-earth in a fine pulverulent state. Into another part of that water I instilled sulphuric acid, whereby a flocculent sediment of sulphat of strontian-earth immediately precipitated. A third portion of this water was mixed with corrosive muriat of mercury (corrosive sublimate), which was immediately decomposed; so that the metallic oxyd exhibited at first a brown-red, and, upon farther affusion of water, an orange-yellow-colour.

Therefore, notwithstanding the violent ignition which it had sustained, only a small part of strontianite had been deprived of its carbonic acid by this experiment; while the other portion still effervesced with acids as strongly as the fresh unburnt strontianite.

b) For a comparative experiment, I subjected *one hundred* grains of *witherite* in a porcelain-crucible to the same degree of red-heat, and for the same time of five hours.

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Its form was no otherwise changed thereby, than that its bulk became somewhat increased; but its transparency was entirely gone; and its colour then inclined to a blueish milk-white. Nor was its weight found to be considerably diminished, by weighing it while yet hot. The water, that had been boiled with it, as in the foregoing experiment, could not be distinguished from pure water, neither by the taste, nor by re-agents. Corrosive sublimate dissolved in it without turbidness; and it likewise continued perfectly limpid, on dropping sulphuric acid into it. The ignited witherite also yielded, on the subsequent affusion of muriatic acid, the same quantity of carbonic acid gas, which is extricated from it, when in the crude state.

## SECOND EXPERIMENT.

a) I caused a piece of *strontianite*, of about half an ounce in weight, to be exposed, in a clay-crucible, to the most vehement heat of the porcelain-furnace. When the vessel had been returned to me, the strontianite was found to have attacked and dissolved the clayey mass of the crucible, and to have run with it into a clear chrysolite-green, very hard, and dense glass.

b) The piece of *witherite*, which, by way of reciprocal experiment, had been exposed in the same manner to the same fire, and under the same circumstances, had likewise strongly acted on the crucible, and was converted into a hard, greenish glass, which, however, was not perfectly compact, but held some air-bubbles.

I repeated this experiment, but with this variation, that I weighed accurately 100 grains of each of these two fossils; and I also exactly noted the weight of the clay-crucibles,

bles, which had previously sustained a violent ignition. By this vitrification the *strontianite* lost 30, and the *witherite* 22 grains; which loss of weight exactly agrees with the proportion of carbonic acid contained in each of those minerals, as will appear from the sequel.

### THIRD EXPERIMENT.

a) In order to ascertain the habitudes of *strontianite*, when exposed to the degree of heat requisite to the baking of porcelain, and debarred from immediate contact with the crucible, I inserted one piece of it, weighing 160 grains, into a cavity made in a compact piece of charcoal, and closed that cavity with a stopper, likewise made of charcoal. This piece of charcoal was then secured in a well luted melting-pot, which I ordered to be put upon that part of the porcelain furnace, where the fire acts in the most intense degree. Upon opening the pot, which was brought to me from the furnace while yet warm, I found the outside of the coal in part consumed\*, and hence lessened in its volume; but the middle and inner part was not in the least impaired. The *strontianite* which had been inclosed in it and burned, re-appeared in its former shape, without any mark of fusion; but with some diminution of its brightness. Its hardness seemed to have increased, rather than decreased, and the colour was outwardly changed to a grey. The loss of weight amounted to  $49\frac{1}{2}$  grains, making 31 in the hundred; and by this it appears, that the *strontianite*.

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\* This phenomenon I have always observed, when employing a similar apparatus. The pores of the crucible are probably more opened by the vehemence of the heat; so that some consumption of the coal may take place on the outside.



had now been entirely deprived, both of its slight portion of water, and likewise of all its carbonic acid; as will be confirmed by the succeeding experiments.

When it had been reduced to powder, and twice boiled with water (one pound of the fluid each time), it entirely dissolved in it; leaving only an inconsiderable residue, which, besides some adhering coal-dust, chiefly consisted of lamellas of carbonated frontian, which was rapidly regenerated.

In the *first* of these decoctions, which immediately after filtration had been preserved in a stopped glass bottle, there appeared crystals in half an hour's time, which visibly increased, and formed an exceedingly beautiful group. These crystals were clear and transparent, of a needle-shaped figure, and aggregated in filiform, knit, or interwoven planes. The whole of them bore resemblance to the crystals of muriated ammoniac: or rather, considering the mostly upright and cellularly implicated facets, which are formed by the accumulation of plumose crystals, it resembles the native silver of Potosi, dendritically crystallized in large laminas.

However, this crystallization of calcined frontian-earth in simple water, without the access of other extraneous substances, is on its own account highly remarkable; even without noticing the beauty of its crystals. This phenomenon is entirely new, and the first instance of an artificial crystallization of a simple earth in mere water.

The *second* decoction of the burned frontianite, that was kept in another glass, likewise afforded, after a few days, some solitary crystals. These, however, had not the plu-

most appearance of the foregoing, but were minute, oblong, quadrangular plates, sharpened on the edges.

The water decanted, proved still of a strong caustic taste, and deposited carbonat of strontian, when carbonated alkali had been dropped into it. The crystals themselves affected the tongue with the like corrosive taste. By exposure to air, they turned opaque and milk-white. A part of them, immersed in muriatic acid, dissolved in it; yet no air at all was developed; and at the same moment I observed acicular crystals of muriated strontian-earth shooting in the solution.

By treating *witherite*, on several repeated experiments, in crucibles formed of charcoal, for the purpose of depriving it entirely of its carbonic acid, I could never completely succeed. That fossil penetrated, and in some manner consumed the substance of the charcoal; and it was again found at the bottom of the outer clay-crucible, in a state of semi-fusion.

#### FOURTH EXPERIMENT.

a) As, in these experiments, I had given the preference to muriatic acid, I first endeavoured to ascertain what quantity of it would be required to dissolve a certain portion of *strontianite*. With this view I mixed 100 grains of muriatic acid, of 1,140 specific gravity, with 50 grains of water, and introduced into this menstruum pure fragments of strontianite, weighing, in the whole,  $62\frac{1}{2}$  grains. After the acid had been fully saturated with it, without the assistance of heat, there remained seven grains; hence  $55\frac{1}{2}$  grains were dissolved and spent in the saturation of the acid. The action of the acid was vigorous, and the solution proceeded with a pretty



pretty strong effervescence. It was necessary to weaken the muriatic acid with half its quantity of water, because, when concentrated and alone, it shews but a weak operation.

Guided by this experiment, I took a quantity of muriatic acid sufficient to dissolve 100 grains of strontianite, and having diluted it with half its quantity of water, I put it upon the balance, and equipoised it on the other scale. These 100 grains of strontianite were then gradually conveyed into the menstruum, and thus the weight of the carbonic acid, disengaged, was found to be 30 grains.

Therefore, *strontianite* contains, in an hundred parts,

|                        |           |                  |
|------------------------|-----------|------------------|
| <i>Strontian earth</i> | . . . . . | 69 $\frac{1}{2}$ |
| <i>Carbonic acid</i>   | . . . . . | 30               |
| <i>Water</i>           | . . . . . | $\frac{1}{2}$    |

---

100

b) To find in the comparative experiment, which I intended to make with *witherite*, the proportion of muriatic acid requisite to its solution and saturation, I prepared a mixture of 100 grains of muriatic acid with 200 of water; this degree of dilution being necessary, to render that acid capable of acting with full energy upon that mineral, and producing a clear solution. Into this mixture were then put 76 grains of *witherite*, in coarse pieces. The saturation of the acid was accompanied by a strong effervescence, and only three grains remained undissolved. One hundred grains of muriatic acid, therefore, required 73 grains of *witherite*, to be completely saturated; and, consequently,  $17\frac{1}{2}$  grains more of it than of *strontianite*.

In consequence of this proportion of muriatic acid to witherite, I now introduced 100 grains of this fossil into a sufficient quantity of that menstruum, which also I previously brought to an equilibrium upon the balance. When its solution was accomplished, the quantity of carbonic acid gas escaped amounted to 22 grains.

Hence, in *hundred* parts of *witherite* are contained,

|                         |    |
|-------------------------|----|
| Barytes . . . . .       | 78 |
| Carbonic acid . . . . . | 22 |

---

100

#### FIFTH EXPERIMENT.

a) If the muriatic solution of *strontianite* be in part evaporated by a low heat, the *middle*, or earthy salt, will shoot in it into fine, longish, needle-shaped, but often, likewise, into larger prismatic crystals, which continue perfectly dry in the air, but readily dissolve in water.

If, upon these crystals, a sufficient quantity of ardent spirit, not too much dephlegmated, be poured, and put in a warm place, they are dissolved by it. The alcohol acquires, by them, the property of burning with a pleasing carmine-red flame, if printing-paper, cotton, and such loose bodies are moistened with it, and set on fire.

b) The muriatic solution of *witherite*, on the contrary, yields oblong hexagonal tables of a much more considerable specific gravity; and likewise these crystals require a greater quantity of water to be dissolved than the others. Their solution, in weak spirit of wine, when set on fire, does not



exhibit the least trace of the red colour in the flame, by which that of *strontianite* is so remarkable. The ardent spirit burns, in this case, only with a yellowish-white flame.

### SIXTH EXPERIMENT.

a) The solution of *strontianite*, in nitric acid, is likewise easily effected. Out of 100 grains of the fossil employed, 30 grains of carbonic acid gas were disengaged, as took place in the fourth experiment, by means of the muriatic acid. The nitrat of *strontian*, which is afforded by this solution, when brought within a smaller compass, by a slow evaporation, forms crystals, which are clear and permanent in the air, the fundamental figure of which seems to be the double quadrilateral pyramid (octahedron), with its usual variations.

b) Nitric acid, employed for the solution of *witherite*, must be more liberally diluted with water, to prevent the too rapid formation of the crystals, which would otherwise take place. These, likewise, seem to be nearly octahedrons; they are, however, less distinct, and, in part, more of a tabular figure. They are, besides, distinguished from those of *strontianite*, by being less clear, and by their dull and opaque appearance.

### SEVENTH EXPERIMENT.

a) By acetic acid *strontianite* is acted upon with little energy. I boiled vinegar, distilled and concentrated by freezing, upon finely ground *strontianite*, and gently evaporated the liquor filtered off from the undissolved residue. It afforded small and clear crystals, that did not deliquesce in the air, and the figure of which appears to consist of thin rhombic tables.

b) An

b) An acetic solution of *witherite*, prepared in the same manner, assumed, at a raised temperature, a tenacious consistence, and congealed upon cooling into a mass, resembling zeolite of the fine fibrous texture. Another solution of this kind, which I left to evaporate spontaneously in a shallow dish under free access of air, I observed to have crystallized in recumbent, very beautiful, ramified dendritic figures of a milk-white colour; or, strictly speaking, it dried in that form. When this *acetite of barytes* had been redissolved in water, it then shot into regular and permanent crystals, forming long, thin, quadrilateral columns, obliquely truncated at their ends.

#### EIGHTH EXPERIMENT.

a) Upon 60 grains of pulverized *strontianite*, introduced in a retort, I poured, by degrees, two ounces of concentrated sulphuric acid. The first portion that was affused caused a great frothing. The contents of the retort were then brought to boiling in a sand-heat. After cooling, the earth was found entirely dissolved, and the solution colourless. But it is again decomposed, as soon as any water is added. If only a few drops of water are instilled into it, it coagulates, and becomes milk-white. One single drop of this solution, thrown into four ounces of water, renders this last turbid, and sulphated strontian-earth falls down.

The concentrated solution afforded, after some days, small, bundled, and stellated crystallizations, the radii of which, as it seemed, were formed by minute quadrangular columns.

b) In like manner, 60 grains of *witherite* were combined with two ounces of strong sulphuric acid. A great effervescence ensued; and, with the assistance of boiling heat, a complete solution, as clear as water, was likewise, in this



case, produced. Some days after, the greatest part of this solution formed a crystalline mass, of very tender fibres. This solution was also immediately decomposed by the admixture of water, and sulphat of barytes precipitated.

### NINTH EXPERIMENT.

a) I decomposed a solution of 100 grains of *strontianite* in muriatic acid, previously diluted with sufficient water, by means of mild vegetable alkali. The earth again took up from the precipitating medium that quantity of carbonic acid, of which it was deprived during its solution in the muriatic acid. Whenedulcorated and dried, it again appeared with its former weight of 100 grains.

b) *Witherite* exhibits the very same habitude in this point. From 100 grains of it, dissolved in that acid, and afterwards precipitated by carbonat of pot-ash, I likewise recovered 100 grains.

### TENTH EXPERIMENT.

It is, however, to be observed, that in these combinations of the respective earths of the *strontianite* and *witherite* with carbonic acid, made by art, this last constituent part is not so obstinately retained by them in a read-heat, as it is when both exist in their natural state.

a) For, when I exposed 100 grains of precipitated *strontian-earth* to intense red-heat during two hours, when upon this I boiled it in two ounces of water, and triturated two grains of corrosive sublimate, with the water filtered off from that decoction, the mercurial oxyd would not dissolve in it, but separated of a yellow-brown colour.

The

The loss of weight, sustained by the ignited strontian-earth, I could not determine with certainty, part of it having united with the body of the crucible. But the diminution of weight cannot have been of great importance; since the torrefied earth still vehemently effervesced with acids.

b) Those 100 grains of earth that had been precipitated from the solution of *witherite*, and were ignited in the same manner, adhered to the crucible with still greater force. The water, with which that earth was boiled after its ignition, nearly in the same manner (a) precipitated the metallic oxyd from the sublimed corrosive muriat of mercury. Likewise the solution of the precipitated earth in an acid, when poured upon it, was still attended with effervescence.

#### ELEVENTH EXPERIMENT.

Neither the solution of *strontian earth*, nor that of *witherite*, is rendered turbid in the least degree, or otherwise altered by caustic ammoniac, even when affused in great excess. But as soon as the slightest portion of an alkaline carbonat is afterwards superadded, an immediate precipitation takes place.

#### TWELFTH EXPERIMENT.

a) Into a muriatic solution of 100 grains of *strontianite* I dropped concentrated sulphuric acid, adding it, by degrees, and till no more precipitate fell down. This, when duly washed, and desiccated in the air, amounted to 114 grains. Of this sulphat of strontian-earth I digested 40 grains, in a boiling heat, with eight ounces of water. The undissolved residue, collected after cooling and dried, was found to weigh  $37\frac{1}{2}$  grains. Therefore,  $2\frac{1}{2}$  grains were dissolved by  
eight



eight ounces of water, which solution, upon the addition of carbonated alkali, yielded a tender precipitate.

b) *One hundred* grains of witherite dissolved in muriatic acid, and precipitated by the sulphuric, furnished  $120\frac{1}{2}$  grains of sulphat of barytes, after being washed and dried in the air.

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It is, then, evident, by the results of these experiments, that there subsists an absolute and natural difference between the earth of *strontianite* and that of *witherite*, or of barytes in general. For, although both these species of earth seem to be nearly of the same nature, with respect to their relations to the sulphuric acid, as well as to the force with which they retain the carbonic acid in the fire; nevertheless many more circumstances exist, which indicate their essential difference. These are, principally,—the less specific gravity of *strontianite* compared with that of *witherite*; the difference of the habitudes of the carbonic acid combined with both of them; the various form of the crystals produced by the combination of these earths with the nitric, acetic, and, above all, with the muriatic acid; the power of *strontian-earth* to crystallize in simple water; and principally, also, the red colour, which the earth of *strontian* imparts to flame in various ways of preparation.

Since, therefore, the *strontian-earth* is peculiarly distinguished by the above enumerated properties, as well as in other respects, there is nothing that can prevent it from being acknowledged and established as a *new, distinct, and simple earth*.

## XIX.

## CHEMICAL EXAMINATION

OF

## LEPIDOLITE.\*

THE fossil brought into notice, by the name *Lilalite*, was first taken for a species of gypsum, and then for a species of Zeolite. The first account published of it is that of *Born*, in the *Chemische Annalen*, 1791, B. 2. S. 196, where he writes of it as follows.

“At *Roxena*, in Moravia, there are found, between blocks  
 “of granite, uncommonly large and heavy masses of a  
 “dense violet zeolite, whose texture, like that of the *aventurino*, exhibits white shining lamellas, that, at the first  
 “view, might be looked upon as micaceous particles. But  
 “these, on more accurate investigation, are found to be  
 “nothing else but white lamellas of zeolite, having the  
 “lustre of the mother of pearl. When ignited between  
 “coals, it fuses to a porous slag. In a strong fire it runs  
 “into a dense, white glass, resembling wax. At an increased heat its colour disappears, which last seems to  
 “originate from manganese. Some pieces of this fossil are  
 firmly implanted on quartz; others are traversed by granite; but, for the most part, it is perfectly pure, and its chief constituent part is silica.

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\* *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v.  
 1 St. S. 59.



To this description, given by *Born*, I may add, that the hardness of this stone is but inconsiderable, as it may be scraped with the nail of the finger. Notwithstanding this, it is capable of some polish when cut into plates.

Its specific gravity is but middling, viz. 2,816 \*

The opinion of those, who thought it to be a species of gypsum, (sulphat of lime) I found totally unsupported. But how justly this fossil may be ranked with the zeolites, will be understood from the result of the present analysis, the subject of which was its amethyst-red variety.

#### A.

a) When this fossil is heated to redness upon charcoal, before the blow-pipe, it first frothes up moderately, but soon after it runs into a perfectly fused milk-white pearl, which, in most of its parts, is transparent; but, if broken by the hammer, yields fragments entirely clear.

b) By a neutral phosphat it is gradually dissolved, and then it fuses into a semi-translucid white pearl.

c) Vitriified boracic acid (glass of borax) dissolves it more readily, and fuses with it into clear colourless spherules.

d) On melting it with soda, in the silver spoon, it moderately boils, and a mass, speckled red and blue, is produced.

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\* The external characters of Lepidolite are described by *Karsten*, loc. cit. pag. 71.

e) Exposed

e) Exposed to red-heat, in a small crucible, for half an hour, it loses its amethystine colour, and that of a light isabella succeeds\*.

## B.

a) Four hundred grains of the levigated fossil, mixed with the same quantity of carbonated pot-ash, were exposed to a moderate red-heat, in a porcelain crucible, for two hours. They did not fuse, but concreted into a considerably firm mass, which, being removed from the vessel before cooling, had a dark verdigris colour, and in some parts an amethyst red. Water which was poured upon it, after grinding, became tinged of a deep grass-green. A few drops of nitric acid changed this green colour to a rose-red. But as soon as sulphureous acid has been added, it immediately destroyed this last colour, and the fluid, under examination, was rendered colourless. This change of colour, therefore, indicated, that the red colour of the fossil is owing to a portion of manganese.

b) I saturated that alkaline fluid with muriatic acid, added to excess, and the solution of the soluble parts was assisted by digestion. This muriatic solution, exhibiting a bright yellow colour, was separated from the *siliceous earth* by filtration; which last proved very much inflated, and, when washed, desiccated, and ignited, weighed 212 grains.

c) After the muriatic solution had been concentrated, by distillation from a retort, it still deposited some *siliceous earth*, amounting to four grains after ignition. By its subsequent

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\* Concerning the habitudes of Lepidolite, in the fire of the porcelain-furnace, see N. 54 of the 1st Essay.



combination with Prussian alkali, a dirty blueish precipitate, of a woolly flocculent form, was thrown down, which, upon ignition, gave a residue of four grains, consisting of intermingled light-brown and grey-white particles. This residue was little, if at all, attracted by the magnet. When fused with phosphated alkali, it formed a milk-white and semi-translucid pearl. Glafs of borax gave it first a green, and then a garnet red colour. Soda produced with it a black scoria, in which, with the help of the microscope, extremely minute, silver-white metallic globules could be seen.

The portion of iron that was contained in the quantity of pruffed pot-ash, requisite to effect that precipitation, makes *one* grain; which being subtracted, there remain three grains for the iron and the manganese, constituting the metallic contents of the stone.

d) I now mixed the solution with caustic (pure) ammoniac. A copious precipitate, in the form of flour-paste, fell down, which I directly separated by filtering. Whenedulcorated, dried, and exposed to gentle red-heat, it was found to be aluminous earth, of 152 grains in weight.

e) The fluid remaining, after the separation of the argil, was combined with carbonated alkalis; but no new precipitate ensued. Therefore, I evaporated the liquor to dryness, dissolved again the saline mass in water, and collected the slight portion of earth which then separated. It weighed three grains, consisting of two grains of *silix* and one grain of alumine.

In the above decomposed 400 grains of the fossil, therefore, existed:

R

Ignited

242 XIX Examination of Lepidolite.

|                                                 |             |     |   |           |
|-------------------------------------------------|-------------|-----|---|-----------|
| Ignited <i>silex</i> . . .                      | B. b) . . . | 212 | } | . 218 gr. |
|                                                 | c) . . .    | 4   |   |           |
|                                                 | e) . . .    | 2   |   |           |
| <i>Alumine</i> . . .                            | d) . . .    | 152 | } | . 153     |
|                                                 | e) . . .    | 1   |   |           |
| <i>Manganese and oxyded iron</i> . c) . . . . . |             |     |   | 3         |
|                                                 |             |     |   | <hr/> 374 |

Which gives for one hundred parts,

|                                             |       |
|---------------------------------------------|-------|
| <i>Silex</i> . . . . .                      | 54,50 |
| <i>Alumine</i> . . . . .                    | 38,25 |
| <i>Manganese and oxyd of iron</i> . . . . . | 0,75  |
| <hr/>                                       |       |
|                                             | 93,50 |
| Loss in aqueous particles . . . . .         | 6,50  |
| <hr/>                                       |       |
|                                             | 100   |

C.

As the fusibility of lepidolite, without addition of any extraneous substance, induced me to suspect, that, among its constituent parts, some *calcareous earth* might be found, I resolved to repeat its analysis.

For this reason, I again subjected 400 grains of it to the same analytical process. Having separated the siliceous earth, the quantity of which was the same in proportion with that of the first process, I treated the solution, then obtained, with mild vegetable alkali, and at a raised temperature. The precipitate produced in the process, and washed, was divided into four equal parts while yet moist.

a) Upon one fourth part I affused *dilute sulphuric acid*, which soon dissolved it into a weak reddish liquor. After a short



short repose, a reddish-grey sediment fell down, which, carefully collected and dried, weighed half a grain, and readily fused upon charcoal to a black-grey scoria. When a small portion of this last had been thrown into melted phosphoric salt, it gradually dissolved, and gave a green tinge to the saline bead. But when the whole of it was put in, the small globule lost its transparency and assumed a blue colour. At the same time a very minute grey-white metallic grain became discernible, which, when separated from the spicule, would not obey the magnet. As that metallic bead hardly weighed  $\frac{1}{32}$  of a grain, it would not admit of farther investigation. Perhaps it was *phosphat of iron*. The saline bead, by imbibing moisture, was again divested of its blue colour, and turned brown-red.

The sulphuric solution, left in a colourless state, after the separation of the above deposition, was committed to spontaneous exhalation; and it then shot, by degrees, into perfect crystals of alum. At last there remained a thickish residue, which, previously diluted with water, and warmed, I combined with vegetable alkali. A slight quantity of a loose, whitish precipitate fell down of  $\frac{1}{3}$  grain in weight, whenedulcorated and dried. By exposure to air, it acquired a brown colour, and by ignition upon charcoal it became black. Treated with a neutral phosphat, with the assistance of the blow-pipe, it soon melted to a small globule, which, by turns, appeared colourless, when acted on by the inner flame, and amethyst-red, by the outer-flame. Thus it proved to be *manganese*.

b) Upon another fourth-part of the precipitate, vinegar, distilled and concentrated by freezing, was affused, and decanted again from it, after 12 hours. In order to try this acetous liquor for calcareous earth, it was divided into three parts, each of which was separately treated; one, with

*oxalic acid*; another, with *oxalat of pot-ash*; the third with *sulphuric acid*. But in no case any indication of lime was observable; all these three trials remaining perfectly clear. The acetous solution merely contained some of argil, which I precipitated from it by pot-ash.

c) The third portion of the precipitate, likewise before drying, was introduced into heated *caustic alkaline lye*: it liquefied in it, leaving a small brownish residue, consisting of the above mentioned metallic ingredient of the stone, together with a slight trace of *filex*.

d) Lastly, the remaining fourth-part of the yet moist precipitate I suffered completely to desiccate in a warm place. The earth was of a milk-white, and weighed 54 grains. It lost nothing of its colour, and but little of its bulk, by a strong ignition for two hours in a small and covered crucible. But its weight was the more diminished, as it then weighed  $37\frac{1}{2}$  grains only.

Therefore, the result of the first analysis was confirmed, as to the main point, by this second decomposition of *lepidolite*.

But the total absence of *calcareous earth*, in the mixture of this fossil, is highly worth remarking. For *filex* and argil, when in their purest state, are absolutely infusible in any proportion of the mixture; but become fusible, when lime in a proportionate quantity enters into the combination. On the contrary, the *lepidolite*, consisting merely of *filex* and argil, and without any portion of lime, is of so easy fusion, that it properly may be reckoned among the most fusible stones.

In many cases, the metallic oxyds, indeed, likewise act as powerful fluxing media; yet, in the present instance, the  
metallic



metallic portion is too small to be capable of being considered, with any degree of probability, as the cause of the fusibility of this fossil.

Is there, perhaps, in those argillaceous stones that fuse in the fire, without any admixture either of absorbent earths or of metallic calces being found in them, some hidden principle, promoting their fusion, which is hitherto unknown, and is of a volatile nature? Fel-spar affords an instance of them. This stone, while continuing in its natural unaltered state, runs into a glass; whereas porcelain-clay, which results from its decay, is infusible in the highest degree. Therefore, it might not seem unreasonable to suppose, that during this transition of vitrifiable fel-spar into infusible clay, some volatile substance, as yet unknown, and capable of promoting fusion, might escape; did we not, on the contrary, find, by experience, that vitrified fel-spar, if again exposed to fire, enters again into fusion, in the same manner as it did the first time.

It remains yet to investigate, whether the lepidolite is justly ranked, as *Born* would have it, among the zeolites. When we attempt, in the mineralogical system, to separate and to determine the various species of fossils, not in a vague manner, but according to fixed characters; the question is, then, in which of its properties does the specific character of zeolite consist? I think, in the following: that it is moderately hard, and gives no sparks with steel; that, urged by the flame upon charcoal, it is rendered milk-white and opaque, swelling much at the same time, and forming ramose excrescences, yet without actually fusing into a globule; and that, besides the siliceous and aluminous earths, the calcareous, likewise, is an essential constituent part of it. The mother-of-pearl-like lustre, the gelatinous coagulum, which it forms with acids, and its phosphorescent

nature on ignition, cannot be considered as any of its essential properties.

Since, therefore, the present fossil does not shew the same appearances upon charcoal as the zeolite, but as it intumesces but moderately, while, at the same time, it fuses into a perfect, and, in part, translucent, round globule; and, moreover, as it is absolutely destitute of lime for one of its constituent parts, these facts afford sufficient ground to distinguish it from zeolite, in the systematical arrangement of fossils, and to rank it as a distinct species.

As I entertained some doubts whether the name *Lilalite*, given to that fossil at its first introduction into public notice, would bear sound criticism, I recommended, in its stead, the denomination of *Lepidolite* (scale-stone), for its *specific name*; because this fossil shines on its fracture like an aggregate of minute fish-scales\*.

A particular fossil has lately been discovered in the vicinity of the lepidolite, which consists of long columnar

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\* A more accurate account of the native place of Lepidolite, together with a full description of its external characters, may be seen in *Fichtel's Mineralogische Aufsätze*, Vienna, 1794, page 226. There the author also endeavours to defend the name *Lilalite*, given to this stone by its first discoverer, the Abbé Poda, of Neuhaus, against mine, *Lepidolite*. But, in my opinion, that appellation is erroneous: 1st, because it is against the common rule to derive the names of *species* from colours, since these are changeable, and since even this very fossil has already been met with, in various shades, of *violet blue*, *amethyst red*, and *white*, besides the *lilac* colour, of which the discoverer first found it. 2dly, Because the word *Lilalite*, being compounded of the Arabic (*Lilac*, *Lilach*), and the Greek (*Lithos*, stone), is a *nomen hybridum*.



crystals, longitudinally striated, and transverfing grey-white quartz, and occurs, with various degradations, of a pale-red colour, in some specimens passing into the ifabella, and into green. This mineral was pretended, by some, to be *crystallized lilalite*: but, even without having yet performed a perfect analyfis of it, I am already convinced, that it by no means belongs to that fossil, but to the *fhörlaceous beryl*, (*fhörlite*,—by Kirwan); with which it agrees not only in its external appearance, but alfo in its habits, in the dry way.

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## XX.

## CHEMICAL EXAMINATION

OF

## CIMOLITE.

THE *Cimolic earth* (*Cimolia Plinii*), or the *Cimolite*, as I shall call it for the sake of brevity, belongs to those bodies of the mineral kingdom, of which an historical knowledge has, indeed, reached our age, from the writings of ancient classics, such as *Theophrastus*, especially, *Dioscorides* and *Pliny*; but a familiar acquaintance with them has gradually been lost since the time of those authors. We learn from the works of those old naturalists, that the Greeks, as well as the Romans, besides its medical use, employed the cimolic earth for technical purposes, in the preparation and cleaning of their stuffs and wearing apparel. This is shewn, among others, in the following passage of *Pliny*\*:—*Cretæ plura genera. Ex iis Cimoliæ duo ad medicos pertinentia: candidum et ad purpurissum inclinans.* And having first mentioned its various applications in medicine, he thus continues: *Est et alius usus in vestibus. Nam sarda, quæ adfertur e Sardinia, candidis tantum adsumitur, inutilis versicoloribus: et est vilissima omnium Cimoliæ generum. Pretiosior Umbrica, et quam vocant Saxum.—Primum abluitur vestis Sarda, dein sulphure suffitur: mox desquamatur Cimolia, quæ est coloris veri. Fucatus enim deprehenditur, nigrescitque, et funditur sulphure.* Veros autem et pretiosos

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\* Hist. Natural, lib. xxxv, chap. lvii.



*colores emollit Cimolia, et quodam nitore exhilarat contristatos sulphure.*

What later writers have mentioned concerning cimolite (*Agricola*\*, for instance), are mere compilations taken out of those ancient authors. *Tournefort*, however, is to be excepted, who certainly saw it in his travels through the Levant, but has erroneously taken it for an earth of the calcareous kind, distinguished from common calcareous earth, as he thought, by its soapy fatness.

It is by the kind communication of *John Hawkins, Esq.* who, in his voyage to the Grecian islands, made for the advancement of Natural History, has collected the genuine cimolic earth on the island *Cimolo* itself, or *Argentiera*, as it is called at present, that I have been enabled to revive the knowledge of this fossil, hitherto lost both to Natural History and Technology, and, at the same time, to undertake its chemical analysis.

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The colour of cimolite is a light greyish-white, inclining to pearl-grey. But this colour is somewhat changed by exposure to air, where it acquires a reddish tint. It is, therefore, probable, that the *cimolia ad purpurissimum inclinans*, of *Pliny*, as well as his *candida*, are both one and the same species; since the first, or the externally reddish one, is, on the fracture, as white as the second.

Cimolite is found *massive*, and probably it occurs in vast strata. Its fracture is *earthy*, *uneven*, and its texture more or less *slaty*. It is thoroughly *opaque*, and does not stain

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\* *De Natura Fossilium*, lib. ii.

*considerably.* When scraped with a knife, it yields shavings, like steatites, and the abraded surface is *smooth*, and of a *greasy lustre*. It adheres pretty firmly to the tongue.

Yet this stone, though it is so soft as to be scraped by the nail, is but with difficulty broken, and, in consequence of this tenacity, not easily pulverized.

Its specific gravity I found exactly double that of water; that is, 2,000.

Small milk-white crystalline grains of quartz are found here and there singly disseminated in its substance.

The flaty texture, which, in the dry pieces of cimolite, is often but confusedly, perceived, appears most distinctly when they are steeped in water. Cimolite is immediately penetrated by water, and it then develops itself into thin laminæ, of a curved-flaty form.

Cimolite, if triturated with water, dissolves into a soft, pap-like mass, though not slippery in the strict sense. *An hundred* grains of it, ground with three ounces of water, assumed the appearance and consistence of a thickish cream. When this mass is left to desiccate in the grinding-dish, it detaches itself from its sides, in hard-dried, ribbon-like, and somewhat flexible bands. In this state, cimolite is pulverized with still greater difficulty than before.

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In order to obtain some knowledge of the efficacy and utility of cimolite, in a technical view, I partially greased small pieces of silk and woollen cloth with oil of almonds, and covered those oily spots, on both sides, with cimolite, work-



worked by grinding with water to the thickness of a lining. They were then exposed to dry in the air. The next day I dipped those stuffs in water, and saw, with surprise, that, by a slight washing, the cimolite, together with all the greasy spots to which it had been applied, were removed, without leaving the slightest trace. After drying, the stuffs were again found possessed of their former cleanliness, and the original beauty of their colours completely restored.

Trivial and imperfect as this experiment was, it served, however, fully to confirm the technical use of cimolite, extolled by the ancient writers: and hence, too, it appears much to surpass the best English fuller's earth. To revive the importation of cimolite, as an article of merchandise, would therefore be very desirable for the manufactures subservient to our clothing, as well as for common use; especially for precious stuffs of delicate colours, that will not well bear the agency of acids and alkaline soaps. Whence, also, the inhabitants of *Argentiera* make as much use of it, in the washing and bleaching of their stuffs, at this very day, as in remote ages.

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To acquire a chemical knowledge of cimolite, I made the following experiments.

A.

a) *Hundred* grains of cimolite, in entire pieces, were exposed, for half an hour, to the fire of the wind-furnace, in a covered crucible. After cooling, it was found grossly split into flaty fragments, of uneven surfaces. This was accompanied, at the commencement of ignition, with a surprisingly strong noise. The cimolite acquired, at first, a brown-

brownish-grey colour, which, however, again disappeared. It lost 12 grains in weight.

b) Ignited, alone, upon charcoal, before the blow-pipe, it first turns dark-grey; but, after complete ignition, it again becomes white.

When cimolite is conveyed into *phosphoric salt*, already fused, it is gradually dissolved by it, and runs into a colourless pearl.

*Glass of borax*, likewise, dissolves cimolite; but is tinged by it of a light-brown.

*Soda* fuses with it into a milk-white globule\*.

## B.

*Hundred* grains of cimolite were triturated with water, and treated with 300 grains of strong sulphuric acid, by which management the white colour of the blended mass was changed to a pale flesh-red. For the purpose of separating the siliceous earth, I evaporated the mixture in a warm temperature, covered it again with water, and subjected it to digestion. However, it continued turbid and muddy; so that I could not fully succeed in separating the filix. I, therefore, employed that mixture to convince myself of the absence, or presence, of magnesia, among the constituent parts of that fossil. With this view, I saturated it, with the assistance of heat, with mild calcareous earth,

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\* The habitudes of cimolite, in the fire of the porcelain-furnace, have been mentioned at No. 27 of the first essay.



and reduced the fluid, when filtered, to a smaller bulk, by evaporation; carefully removing, at the same time, the selenite, as it appeared. Yet no trace of sulphat of magnesia was perceptible.

## C.

a) Two hundred grains of cimolite, mixed, and ignited with thrice their quantity of caustic pot-ash, afforded, after cooling, a blueish, and greenish-white mass. From this, when softened with water, the undissolved part was separated by filtering.

b) The alkaline liquor had no colour. It at first continued clear, on being saturated with sulphuric acid; but, at a raised temperature, it coagulated to the consistence of jelly. Upon the affusion of more water, and proper digestion, *siliceous earth* separated, weighing 44 grains, when ignited.

c) The earth, which was not taken up by the alkali (a), was of a grey white, and weighed 220 grains. It dissolved, by degrees, in sulphuric acid, which was added to it, and left behind some *siliceous earth*, which weighed five grains, after ignition.

d) Both the sulphuric solutions (b) and (c) were next added together, and partly evaporated; after which, crystals of alum appeared, as the liquor cooled. The remainder of the fluid congealed, on farther evaporation, to a jelly. When mixed with water, digested, and filtered, there remained *siliceous earth*, in the form of pellucid vitreous grains, the weight of which, after grinding and ignition, was 64 grains.

e) I now combined the solution with Prussian alkali, which produced a deep-blue precipitate; by the quantity of which the proportion of the ferruginous ingredient, in the form of *oxyd of iron*, attractible by the magnet, was determined at  $2\frac{1}{2}$  grains.

f) When the portion of iron had been separated, I added a small quantity of vegetable alkali to that part of the solution which yet remained. By this treatment, and subsequent evaporations, I obtained aluminous crystals, in succession, to the end. But, at the same time, there still separated some *siliceous earth*, amounting to 13 grains, when heated to redness.

g) The whole of the alum (sulphat of alumine) obtained, was re-dissolved in water, and the argillaceous earth separated by vegetable alkali. This argil, depurated and ignited, gave 46 grains in weight.

Therefore, the above 200 grains of *cimolite* produced :

|                             |       |                          |                                 |
|-----------------------------|-------|--------------------------|---------------------------------|
| Ignited <i>Silex</i>        | C. b) | . 44                     | } 126 grains.                   |
|                             | c)    | . 5                      |                                 |
|                             | d)    | . 64                     |                                 |
|                             | f)    | . 13                     |                                 |
| <i>Alumine</i>              | g)    | . . . . . 46             |                                 |
| Ignited <i>oxyd of iron</i> | c)    | . . . . . $2\frac{1}{2}$ |                                 |
| <i>Loss by ignition</i>     | A. a) | . . . . . 24             |                                 |
|                             |       |                          | <hr/> 198 $\frac{1}{2}$ grains. |

Whence, *one hundred parts of cimolite* contain:



XX. Examination of Cimolite. 255

|                     |   |   |   |   |   |      |
|---------------------|---|---|---|---|---|------|
| <i>Silex</i>        | . | . | . | . | . | 63   |
| <i>Alumine</i>      | . | . | . | . | . | 23   |
| <i>Oxyd of iron</i> | . | . | . | . | . | 1,25 |
| <i>Water</i>        | 4 | . | . | . | . | 12   |

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99,25

With regard to these constituent parts, and their proportions to each other, the *cimolite* might properly be placed in the mineralogical system along with the common species of clay : but its distinguishing character, on which, also, its other physical properties depend, undoubtedly consists in the minutely divided state of the siliceous ingredient, as well as the most intimate mixture of this last with the argillaceous part.

## XXI.

## CHEMICAL EXAMINATION

OF THE

*MAGNESIAN-SPAR (Bitterspath.)*(Crystallized Muricalcite, *Compound Spar*, of Kirwan.)

A\*.

AMONG the Tyrolese fossils, and those of Salzburg, so remarkable by their variety, there occur certain rhombic crystals, which are most frequently found singly interspersed in a slaty chlorite (*Schneidestein*), mixed with silver-grey magnesian lamellas. Those crystals have been called *rhomboidal spar* on account of their figure, or *magnesian-spar* (*Bitter-spath*) on account of this supposed constituent part.

The colour of those crystals is greyish-white, passing more or less into yellow or reddish. They commonly form regular rhombs, from one half to three fourths of an inch thick; but they are also found of a greater size. Their external splendour is only moderate; but internally they possess a high lustre. Their fracture is of the straight foliated kind; but the figure of their fragments is rhomboidal. They are mostly *transparent* in a great degree; but the fragments of the larger crystals are nearly *pellucid*; and if held against the light, they exhibit changing

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\* *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v. page 51.



rainbow-colours. Their hardness is a medium between that of calcareous-spar and that of fel-spar; as the first may be scratched by them, but they themselves may be scratched by the second\*.

Their specific gravity I have found to be 2,480.

a) An entire piece, weighing 100 grains, was ignited in a covered crucible for two hours; yet, notwithstanding its sparry texture, it remained entire, without flying in pieces. It was rendered ash-grey, and wholly opaque, though preserving some lustre. At the same time its weight was lessened 45 grains†.

b) The action of mineral acids upon magnesian-spar, while in gross fragments, is not perceptible; but if pulverized, they attack and dissolve it gradually, attended with a continued gentle effervescence. With the sulphuric acid, selenite is generated, and the supernatant solution is of a pale-reddish colour. Nitric acid produces a colourless solution, and the muriatic acid a yellow one.

But when pieces of calcined magnesian-spar are employed, the solution goes on rapidly. And in that case the nitric acid leaves a metallic residue behind, which separates of a brown-red colour.

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\* More circumstantial descriptions of the external characters of this fossil have been given by *Karsten* in *Beob. u. Entd. a. d. Naturk.* vol. v. page 56.—*Born Catal. d. l. Collect. d. Fossils*, vol. i. page 386, with the name, *Chaux magnésée*;—and *Fichtel. Minér. Aufsätze*, page 189.

† For the habitudes of *magnesian spar* in a porcelain-heat, see N. 16 of the first Essay.

c) *Three hundred* grains of finely powdered magnesia-spar, mixed with an equal quantity of pot-ash, were ignited for two hours in a crucible. The mass returned black out of the fire, except that its middle part was rendered of a dark ash-grey. When triturated, and covered with water, it became light-green. Muriatic acid affused upon it, in sufficient quantity, dissolved the whole, forming a clear golden-yellow tincture.

d) This solution was decomposed by means of carbonated pot-ash, and with the assistance of heat. Sulphuric acid was poured upon the precipitate, previously diluted with water, in such a quantity that the acid was predominant. Abundance of selenite (*fulphat of lime*) was thus produced; which separated from the remaining fluid.

e) I next evaporated the solution, that remained after the separation of the selenite, and which contained fulphat of magnesia, and a small portion of fulphated oxyd of iron; carrying on the operation, until the saline mass appeared in a dry state. This last I subjected to a red-heat for two hours, re-dissolving it afterwards in hot water. Upon the filter there remained a subtle red-brown oxyd of iron, weighing nine grains, and wholly obeying the magnet.

f) The solution, now freed from the iron, afforded, by crystallization, a pure fulphat of magnesia; which, when properly decomposed by pot-ash, and with the assistance of heat, yielded 133 grains of *carbonated magnesia*.

g) The fulphat of lime (d), decomposed by dissolved carbonat of pot-ash, furnished 160 grains of crude calcareous earth. To examine whether this last still contained any magnesia, I dissolved it again in nitric acid, mixed the solution with caustic ammoniac, and filtered the precipitate then



then formed. This immediately dissolved in sulphuric acid, which was added, and being precipitated by carbonated potash, it still yielded three grains of magnesian earth; which subtracted, leaves, therefore, 157 grains for the quantity of crude calcareous earth, or *carbonat of lime*.

Consequently, I obtained from the above 300 grains of the *Tyrolese magnesian-spar*:

|                                                    |              |           |     |                |
|----------------------------------------------------|--------------|-----------|-----|----------------|
| <i>Carbonat of lime</i>                            | . . . g)     | . . . . . | 157 | grs.           |
| <i>Magnesia</i>                                    | . . . . . f) | 133       | }   | . . . 136      |
|                                                    | . . . . . g) | 3         |     |                |
| <i>Oxyd of iron</i> , containing<br>some manganese | . . . . . e) | . . . . . | 9   |                |
|                                                    |              |           |     | <hr/> 302 grs. |

As no loss of weight, but rather an excess, appears in the sum of the constituent parts, given separately, we may conclude, that those ingredients might, perhaps, have been capable of undergoing a still greater degree of desiccation.

Therefore a hundred parts of *magnesian-spar* consist of:

|                                                  |           |           |
|--------------------------------------------------|-----------|-----------|
| <i>Carbonat of lime</i>                          | . . . . . | 52        |
| <i>Magnesia</i>                                  | . . . . . | 45        |
| <i>Oxyd of iron</i> , impregnated with manganese | . . . . . | 3         |
|                                                  |           | <hr/> 100 |

B.

Although it is only a few years since this fossil was brought to Vienna by some Tyrolese dealers in minerals of their country, and from thence brought into farther notice; yet it seems that Woulfe has already been acquainted  
s 2 with

with it at an earlier period. For the fossil, which he examined, and described in the *Philosoph. Transf.* for 1779\* by the name of *compound spar*, agrees with the Tyrolese.

It is also proved, that the magnesian-spar is found not only on the borders of the Tyrolese and Salzburg mountains, but likewise in other places, by the following examination of a spar of that kind, coming from *Taberg*, in *Wermeland*, a province of Sweden.

It occurs in the fossil, in which I have found it of a grey-white colour, with a strong lustre, nearly resembling that of the mother of pearl, in semi-pellucid and rhomboidal fragments. With regard to its fracture, it can hardly be distinguished from that variety of the Tyrolese magnesian-spar, which furnished the subject of the foregoing analysis. The only difference consists in its external form; that is, it does not occur in single interspersed crystals, like the last, but in masses; and it is accompanied by a green, compact, indurated clay, and a gross-foliated, deep verdigris-green *talc* (magnesian earth.)

a) A small piece of it, ignited *per se* upon charcoal, turns brown without splitting. It dissolves, by fusion, in a neutral phosphat, and forms a clear, colourless bead. Nearly the same effect is produced by *glass of borax*. When heated to redness with soda on the melting-spoon, it fuses into a dull, blueish-green globule.

b) Two hundred grains, reduced to powder, dissolved gradually, and with effervescence, in the muriatic acid. Caustic ammoniac, added to the yellow solution, produced a light flocculent precipitate of a dirty green, which on the fil-

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\* *Kirwan's Elements of Mineralogy*, Lond. 1794. vol. i. p. 92.



tering paper changed to a brown, and, heated to redness, yielded  $4\frac{1}{2}$  grains of *oxyd of iron*.

c) The solution, now rendered colourless, was evaporated to a smaller compass, mixed with one third part of alcohol, and combined with as much sulphuric acid as was necessary to precipitate the siliceous earth from the felenite or gypsum (*fulphat of lime*), which was then separated, and washed with a mixture of alcohol and water.

d) When the whole of the liquor had been again reduced by evaporation, I precipitated its magnesian earth, by means of carbonated pot-ash, assisted by a boiling heat. It did not prove to be as loose as it ought to have been, and thus it shewed, that it was not yet pure. Hence, on the affusion of sulphuric acid upon this precipitate, more felenite was deposited, which I added to the first. The solution, thus freed from it, then afforded pure fulphat of magnesia (*Epsom-salt*), which, re-dissolved and decomposed in a boiling heat, by alkaline carbonat, afforded 50 grains of *carbonated magnesia*.

e) The felenite also was decomposed, by boiling with water and carbonated pot-ash. Thus I procured from it 146 grains of mild, or *carbonated calcareous earth*.

This *Swedish* magnesian-spar, therefore, contains much less magnesia than the *Tyrolese*; and the proportion of its constituent parts in one *hundred* is the following :

|                                                           |        |
|-----------------------------------------------------------|--------|
| <i>Carbonat of lime</i> . . . . .                         | 73     |
| <i>Magnesia</i> . . . . .                                 | 25     |
| <i>Oxyd of iron</i> , containing a little manganese . . . | 2,25   |
|                                                           | <hr/>  |
|                                                           | 100,25 |
|                                                           | XXII.  |

## XXII.

## EXAMINATION

OF THE SUPPOSED

*MURIACITE.*

THE review of our present knowledge of mineral bodies would undoubtedly be much more extensive, and at the same time require much fewer corrections, if every newly discovered fossil were immediately put to the chemical test, and not received into the systematical arrangement, till it had been stamped with the authentic seal of truth.

The *muriacite* does not seem to be as yet so generally known, that I may not hope to be able to prevent its farther introduction to the public in an erroneous shape, by means of the examination which I am going to describe.

*Fichtel*\* gives the following account of it.

Abbé Poda has lately discovered a new species of calcareous earth, which, by reason of its constituent parts, he calls muriated lime, or *muriacite*, according to the new method of nominating fossils; because that mineral is composed of calcareous earth, *muriatic acid*, and water. The miners in the salt-pits at Hall, in Tyrol, call it scaly gypsum (*schuppiger gyps-stein*.) But, besides this difference in its constituent parts, it is also farther distinguished from the compact gypsum: 1st, by its greater hardness; 2dly, by the quadrilateral,

\* See his *Mineralogische Aufsätze*. Vienna, 1794, page 228.

rectangular.



rectangular scales or laminas, of which it is entirely composed; and 3dly, by its much more difficult solution in water, of which, at a mean temperature, it requires 4300 parts. We expect to receive from the Abbé himself the circumstantial description of this new species of calcareous earth.

This fossil the more deserved a chemical examination, as hereby we might be enabled to understand by what means Nature could produce a combination of the earthy saline kind, which in the dry as well as in the crystallized state is so much disposed to deliquescence; but which, as here is supposed, exists in a dry and compact state, and at the same time requires such an excessive quantity of water to be dissolved.

That specimen, which has been sent me from *Vienna*, as genuine *muriacite* of *Hall*, in *Tyrol*, is an aggregate of rectangular, four-sided plates, of a light-grey, black-grey, and in part reddish colour, with bright specular surfaces; and hence not ill resembling gross-foliated hornblende. (By the taste, and partly even by bare inspection, it betrays an admixture of some portion of rock-salt. Trituration reduces it to a white-grey powder.

a) Upon five hundred grains of it alkohol was poured; which, after 24 hours, I again separated by filtering. The ardent spirit continued colourless; and when evaporated, it left pure common salt, or muriat of soda, behind, in the state of dry crystals.

b) This being done, water was affused upon the powder, until all the saline parts were lixiviated. This aqueous solution, which was likewise colourless, being evaporated to dryness, left also common salt behind; but contaminated with *gypsum*.

264 XXII. *Examination of Muriacite.*

c) The salt obtained in both extractions, and added together, weighed 91 grains. By the affusion of *one* part of alcohol, mixed with three of water, all the salt was dissolved, and the residual *gypsum* amounted to 17 grains. This determines the quantity of the *muriat of soda* at 74 grains.

d) I next treated the powder (which had been previously extracted both by alcohol and water) with dilute nitric acid; digesting it gently. Carbonated pot-ash, added to the nitrated fluid which was again separated, threw down an earth, weighing 26 grains when dried, and consisting of *calcareous earth*, impregnated with iron.

e) The residue was boiled with water and carbonated pot-ash. The fluid, filtered off, was then saturated with nitric acid. By the addition of muriated barytes, a precipitate was obtained, consisting of sulphat of barytes.

f) Upon theedulcorated residue I poured again some nitric acid, which produced a great effervescence. After due digestion I separated the fluid by filtration; and, while yet boiling, I combined it with alkali, by which treatment I obtained 76 grains of *carbonated lime*. But as this last had existed in the fossil, in a state of combination with the sulphuric acid, mentioned at (e), we must only reckon 120 grains of gypsum, or *sulphat of lime*.

g) What remained, after the extraction with nitric acid, weighed now 265 grains. It was a minute, light-grey, micaceous sand.

In these 500 grains of the fossil, therefore, have been found:

*Muriat*



## XXII. Examination of Muriacite. 265

|                            |    |           |                 |
|----------------------------|----|-----------|-----------------|
| Muriat of soda . . . . .   | c) | . . . . . | 74              |
| Gypsum . . . . .           | e) | 17        | } . . . . . 137 |
|                            | f) | 120       |                 |
| Carbonat of lime . . . . . | d) | . . . . . | 26              |
| Sandy residue . . . . .    | g) | . . . . . | 265             |

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502 grs.

Hence, the existence of a *native muriat of lime* in the *concrete state*, and also the name of *muriacite*, which has been given to it, are incompatible with this result.

XXIII.

## XXIII.

## EXAMINATION

OF THE

## NATIVE ALUM

*From Miseno.*

THE alum cavern (*grotta di alume*) at the Cape *Miseno*, near *Naples*, which, as it were, serves as a laboratory, where Nature alone, unassisted by art, is constantly producing perfect alum, has been mentioned only by few of the Naturalists who have visited that country. Professor *Spallanzani*\* says of this remarkable grotto:—*Before the traveller reaches the promontory Miseno, he meets with its harbour, which, there is no doubt, is likewise a crater; as it is surrounded on all sides with eminences. Those elevations consist of tufas, and on one side of them, a little above the sea, there is seen an aperture, made by art, which is called grotta di Miseno; and where sulphat of alumine (alum) continually effloresces. This salt is not known by the natives, or at least they pay no attention to it.*

The subject of the following analysis has been a portion of the alum of *Miseno*, collected on the spot itself, and given to me by that worthy naturalist, *John Hawkins*, Esq.

All saline efflorescences agree in this, that while they continue in the dry state, they give no sign of the crystalline figure, that is peculiar to each particular species of salt. They always appear of a fibrous form. For this



reason also, this effloresced native alum does not present its appropriate octahedral form, but is found in small, detached, and roundish accumulations, of very thin and short fibres, possessed of a white colour, and silky lustre, though in part intermingled with minute crystalline grains.

a) One thousand grains of this native alum, dissolved in 10 ounces of boiling water, left 120 grains of a yellowish-grey earth on the filtering paper.

b) The clear solution, when evaporated for the purpose of crystallization, gradually, and alone, afforded 470 grains of pure, clear alum, in octahedral crystals; although their formation had not been promoted by the addition of pot-ash. At the same time 25 grains of *selenite* (gypsum) appeared.

c) Those 470 grains of crystallized alum, re-dissolved in water, were decomposed, while yet boiling, by carbonated lime. After the separation of the gypsum then generated, I evaporated the remaining fluid, along with the washings, to a smaller bulk, and freed it from the selenite, which still continued to appear. It yielded 27 grains of *sulphat of pot-ash*.

d) After this, the remainder of the solution of the crude alum, that would no longer shoot into solid crystals, was inspissated, by farther evaporation, to a grey-white, unctuous mass; being but an imperfect sulphat of alumine. This substance might, in the present case, be considered as a true *mineral butter* (*Bergbutter*). By affusion of water it formed a somewhat turbid solution; and, by being then treated with a small portion of pot-ash, it yet afforded 290 grains of concrete *crystals of alum*.

e) The

e) The above 120 grains of earthy residue (a) were boiled with mild vegetable alkali and water. The filtered liquor was then saturated to excess with muriatic acid, and combined with muriated barytes. Upon which sulphat of barytes fell down.

f) I now drenched in muriatic acid the residue, that had been boiled with alkali. This last, again separated from it by the filter, was next saturated with carbonated pot-ash. Eleven grains of a yellowish earth were then precipitated; which, upon closer examination, were found to consist of two grains of oxyd of iron, and nine grains of carbonated lime; which last, together with that which had been indicated in combination with sulphuric acid by the muriated barytes (e), amounted to 15 grains of selenite.

g) The final remainder, which had resisted the attack of the muriatic acid, weighed 92 grains, and was a sandy earth, of a greenish-grey colour, meager, and harsh to the feel.

From 1000 lbs. therefore, of this rough, native *alum* from *Miseno*, may be produced, barely by solution in water, and subsequent crystallization:

- |                                                                                     |     |
|-------------------------------------------------------------------------------------|-----|
| 1) Alum, provided by Nature herself with<br>the requisite quantity of pot-ash . . . | 470 |
| 2) Alum, whose crystallization is pro-<br>moted by adding pot-ash . . . . .         | 290 |

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760 lbs.

When, therefore, *Spallanzani* censured the natives for not knowing, or for disregarding this natural product, which is so easily procured, and which, with so little expence,



pence, may be made a profitable article of commerce, he was not unsupported by reason. This alum of *Miseno*, it should seem, might be of the same good quality as that of *Tolfa*; as it can be rendered as free from iron as this last, and, as besides, the proportion of sulphated pot-ash would not be greater in it than in the Roman alum.

This portion of sulphat of pot-ash, contained in the alum from *Miseno*, occasions the following question; which indeed it will be still difficult to answer at this time.—It is: As this grotto consists merely of volcanic tufa, in which no vegetation takes place, whence does Nature procure the vegetable alkali, requisite to the generation of the crystallizable alum?

*Note.* Another instance of the like daily production of *native alum* occurs at *Solfatara*, where it is procured, and refined after the manner described by Prof. *Breislak*. From the following passage of his: *Essais Mineralogiques sur la Solfatare de Pouzzole*, Naples, 1792, page 157, it appears—That it is upon the ground of the production of these saline efflorescences, the abundance and richness of which are equally surprizing, and, likewise, of the excessive promptitude of their re-production, that it has been resolved on to establish at *Solfatara* a manufacture of alum, which of late has been put in activity by *Joseph Brenzani Cimaroli*.—In the fuller account of it, given page 231, according to which, the aluminous lixivium, by means of boiling, is brought to shoot into crystals in no longer time than 24 hours, there is no mention made of any artificial addition of pot-ash. It is therefore probable, that the alum of *Solfatara*, like the above of *Miseno*, is already by Nature provided with that portion of pot-ash, which is necessary to the production of perfectly crystallized alum.

## XXIV.

## EXAMINATION

OF THE

*NATIVE SALT-PETRE (Nitre),**From Molfetta.*

THE discovery of the native salt-petre-mine, or of the *Pulo*, producing nitre at *Molfetta*, in *Apulia*, made by Abbé *Fortis*, in the year 1783, could not fail to attract the attention of naturalists, in a degree proportionate to the importance of the subject.

Various philosophers, who have visited and examined the *Pulo* since its discovery, have already given circumstantial descriptions of the natural state of that remarkable pit, as well as an account of the great quantity of nitre which it affords, and of its incomprehensible daily re-production. As to these descriptions, I shall refer the reader chiefly to those published by Prof. *Zimmermann* of *Brunswick*\*, and by *de Salis Marschlin*†.

The nitre employed in the following analytical experiments was collected by *John Hawkins, Esq.*, who has examined that nitre-pit in the *March* of 1788, in company

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\* *Voyage à la Nitrière Naturelle, qui se trouve à Molfetta*, par M. *Zimmerman*. Paris, 1789.

† *Reisen in Verschiedene Provinzen des Königreichs Neapel*. 1st vol. Zurich and Leipzig.



with Zimmermann and Fortis. In the specimens which I was favoured with, the salt-petre invested fragments of a yellowish-white, compact, lime-stone, forming the stony matter of the *Pulo*. These fragments, detached from the rock in thin layers, are incruited with the salt, to the thickness, for the most part, of one sixth of an inch; when it appears in a finely-grained, crystalline form, resembling white refined, or Canary sugar. On some parts of the lime-stone I discovered thin incrustations of a finely-fibrous gypsum, which, in some places, served as a base for the nitre to rest on.

a) One Thousand grains of this native salt-petre, together with the lime-stone and gypsum to which it adhered, were covered with boiling water. The remaining lumps of stone having been lixiviated, the clear and colourless solution, thus obtained, was next prepared for crystallizing by gentle evaporation. Each shooting of the salt was accompanied by tender, needle-shaped, selenitic crystals. No mother-water remained: but the whole of the solution crystallized, to the last drop, to a perfect prismatic nitre. The selenite, separated from the salt as much as was possible, weighed 40 grains; whereas the salt gave 446 grains.

b) According to researches of Professor Vairo\*, this nitre is said to contain common, or sea-salt, in the proportion of 1 to 6. I therefore expected to obtain, besides the prismatic crystals of the salt-petre, some sea-salt also, in distinct, solitary cubes: but no trace of it, visible to the eye, appeared. For this reason, I attempted to discover its presence by another method. With this view, I re-dissolved, in water, the crystals of nitre which I had obtained, and

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\* *Voyage à la Nitrière Natur. Zimmerman, page 35.*

dropped dissolved acetite of barytes into the solution. By these means I obtained a precipitate, consisting of 26 grains of sulphated barytes; which shewed, that  $18\frac{1}{2}$  grains of selenite were still united with the neutral salt. When, after this, I tried the nitrous solution with muriated silver, no more than  $4\frac{1}{2}$  grains of hornsilver (*muriat of silver*) would precipitate, so that the quantity of common salt, indicated by this last, can be estimated at only two grains. By this, the true quantity of perfectly pure nitre has been reduced to  $425\frac{1}{2}$  grains.

However, I think it more probable, that the neutral muriat, which was mixed with the native nitre, was not muriated soda, but a *muriat of pot-ash*, or digestive salt, as it is called.

c) Upon the stony substances remaining after the lixiviation of the crude nitre, and which exactly constituted one half of the first weight, viz. 500 grains, I poured muriatic acid. The pieces of lime-stone dissolved with great effervescence; leaving a residue of 196 grains behind, which were white gypsum, of delicate fibres. When the sulphuric acid had been separated from this last, by boiling it in water with carbonated pot-ash, there remained some carbonat of lime, which dissolved, without any residue, in nitric acid.

The *lime-stone*, taken up by the muriatic acid, consequently amounted to 304 grains; and, being subjected to farther trial, it proved to be merely calcareous earth, containing a small portion of iron.

Hence, these 1000 grains of *nitre from Miseno*, here decomposed, have consisted of:

*Pure*



|                       |    |                  |                           |
|-----------------------|----|------------------|---------------------------|
| Pure prismatic nitre  | b) | . . .            | 425 $\frac{1}{2}$ grains. |
| Muriated neutral salt | b) | . . .            | 2                         |
| Selenite              | a) | 40               | } 254 $\frac{1}{2}$       |
|                       | b) | 18 $\frac{1}{2}$ |                           |
|                       | c) | 196              |                           |
| Lime-stone            | c) | . . .            | 304                       |
|                       |    |                  | <hr/> 986                 |
| Loss                  |    |                  | . 14                      |
|                       |    |                  | <hr/> 1000                |

By the computation of Prof. *Vairo*\*, the total mass of salt-petre in the *Pulo* should amount to between 30 and 40 thousand centners, at 100 lb. each; and the second reproduction of it to more than 50 thousand centners. As, therefore, the alkaline base of prismatic nitre constitutes nearly one half of the whole of that compound, it is obvious, that the question which I have intimated at the close of my last essay, concerning the origin of the vast quantity of vegetable alkali, becomes, in the present case, far more important and interesting to the naturalist. The conjecture, that Nature possesses means of producing that alkali beyond the limits of the vegetable kingdom, nay, even without any immediate influence of vegetation, acquires, by this singular phenomenon, a very high degree of probability.

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\* Loco Citato. Page 37.

## XXV.

CHEMICAL EXAMINATION  
OF THE  
*MINERAL SPRINGS, at Carlsbad.*

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AMONG the hot mineral springs of Germany, that at *Carlsbad*, in *Bohemia*, deserves the particular attention, not only of the physician and the philosopher, but also of every individual that has a due sense of the grand scenes in nature.

The basin of the main-spring, that wonderful reservoir, is, perhaps, the only one of its kind, which Nature herself has formed of the constituent parts of the spring, and, at the same time, has covered it by a triple marble-vault, fitted for the collection of the mineral waters produced in the neighbouring subterraneous laboratory. The boiling main-spring, rushing, with vehemence, out of the principal apertures of this water-vault, and filling the atmosphere with vaporous clouds ;—the incessant play of the air-bubbles, forcing their way through the smaller rifts and fissures, and rising in the form of pearls through the river *Töpel*, which flows immediately upon a considerable part of that vaulted roof of the spring :—all this, at the first view, invites the mind to reflection ; at which the spectator can hardly avoid falling into the pleasing illusion of seeing Nature, that usually likes to operate in a hidden manner, working here close at hand, and, as it were, before his eyes.

I think



I think it needless to enter into a topographical and physical description of *Carlsbad*; because there already exist several accounts and descriptions of it. Among these, the *Treatise on Carlsbad*, by Dr. *Becher*, may be considered as the most capital work. I shall, therefore, suppose the reader acquainted with its contents; which, also, in general, I refer to in this essay.

My principal design is, to state our observations, and the constituent parts of the *Carlsbad-water*, the decomposition of which we attempted\* at the spot itself, in July 1789; as well as to compare them with those given by Dr. *Becher*. Besides this, I also intend to say something of the manner which Nature, probably, adopts, in elaborating this mineral spring, by way of a small addition to the theories that have been already offered on this head.

In our researches, we confined our experiments to the three principal springs: the main-spring, the *new spring*, and that in the *castle*. Upon the whole, these, like the other collateral springs that are less made use of, agree with each other in their constituent parts, as well as in the proportion of the more fixed parts, which, in all of them, is much the same. But they differ considerably from each other in their share of carbonic acid; and this variation is regulated by the temperature, which in one spring exceeds that of another; the quantity of carbonic acid being in the inverse ratio of that of the heat. And for this reason, of the above-mentioned three springs, main-spring the hottest of all, and whose temperature, upon an average, is of 165° of Fahrenheit's thermometer, contains the least of the acid.

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\* For I had the pleasure of making these experiments in company with Count *Gesler*, Chamberlain and Privy-counsellor to the King of Prussia.

The spring at the castle, on the contrary, the temperature of which is raised only to  $120^{\circ}$  or  $125^{\circ}$  *Farenh.* contains the greatest portion of carbonic acid\*.

To save the trouble of a tedious enumeration of the experiments made, I shall give only a short description of our method of proceeding, and mention the results in a summary way.

The constituent parts of the mineral-water of Carlsbad are, in general, *carbonat of soda*, *sulphat of soda*, (Glauber-salt), and *uriat of soda*, or common salt; besides these, *carbonated lime*, *siliceous earth*, and a slight trace of *oxyd of iron*: and, lastly, a proportionate quantity of free, carbonic acid, or, to characterize it more precisely, of *carbonic acid gas*, solely absorbed by the water; besides *free caloric*.

On attempting to separate and to catch or obtain the carbonic acid gas, we proceeded in the following manner:—A glass-retort, of 23 cubic inches capacity, was filled with 18 cubic inches of water, taken from the pipe of the spring-head; and we lodged it immediately in the sand-pot of a pneumatic distilling apparatus, purposely placed near the spring. The first receiver, into which the neck of the retort was inserted, and the glass-cylinder employed to collect the extricating gas, had been filled with hot-water from the

---

\* When we visited *Carlsbad* a second time in July 1792, we found the temperature of the

|                          |                 |                     |
|--------------------------|-----------------|---------------------|
| Atmosphere . . . .       | 20              | } Degrees, Reaumur. |
| Spring at the castle . . | $37\frac{1}{2}$ |                     |
| New-spring . . . .       | 48              |                     |
| Liebschen-spring . . .   | 55              |                     |
| Main-spring . . . .      | $55\frac{1}{2}$ |                     |

spring.



spring. Under these circumstances, we expected that the gas would immediately disengage itself, and pass over, at the very first action of the heat on the retort; this, however, happened only a little before the commencement of actual boiling; which last we continued until no more air-bubbles came over.

The air collected in the cylinder amounted to  $10\frac{1}{2}$  cubic inches. When, therefore, the five cubic inches of atmospheric air, that remained in the retort before the operation, are subtracted, the portion of gas, disengaged from 18 cubic inches of Carlsbad-water, at the main-spring, consists of  $5\frac{1}{2}$  cubic-inches. These were entirely absorbed by lime-water, and a calcareous precipitate was produced; so that nothing remained but the five cubic-inches of atmospheric air. By this, and by several other trials, we were convinced that the gas, disengaged by that mineral water, consists of pure *carbonic acid*; that the sulphurated hydrogen gas, which various authors have supposed to exist in it, along with the carbonic acid, is never present; and that the presence of *sulphureous acid*, together with uncombined soda, as some others have imagined, is not even so much as possible.

By the same management, and under the same circumstances, an equal quantity of the water of the *new-spring* afforded nine cubic inches, and of the *spring at the castle*  $9\frac{1}{2}$  cubic inches, of carbonic acid gas.

I will allow that, by this method of collecting and measuring the carbonic acid gas, the highest degree of accuracy was not, perhaps, so certainly obtained as it would have been by properly employing the pneumatic quicksilver apparatus, which, at that time, was not in our power at Carlsbad. Nevertheless, I am convinced that this method

of conducting and collecting the disengaged gas, through and by means of the hot water of the main-spring, instead of employing mercury for that purpose, cannot have occasioned any considerable difference in the result: for water, in general, when of equal temperature with the natural warmth of the Carlsbad main-spring, is not capable of absorbing a notable portion of carbonic acid. And, besides, such an absorption of that acid gas could the less have taken place in the present instance, as that water, being naturally impregnated with as much carbonic acid as it can contain, was incapable of taking up an additional quantity of that acid.

If this proportion of carbonic acid, found in the above-mentioned three springs at Carlsbad, be compared with that given by Dr. *Becher*, which, calculated to eighteen cubic inches of water, would amount to seven cubic inches in the main-spring, to  $6\frac{1}{2}$  in the new-spring, and to 10 in that at the castle, there, indeed, occurs a difference; since, in our experiments, the carbonic acid extricated from 18 cubic inches of the main-spring water measured  $1\frac{1}{2}$  cubic inch, and from that at the castle  $\frac{1}{2}$  inch less than Dr. *Becher*'s results, whereas that obtained from the water of the new spring, measured  $2\frac{1}{3}$  cubic inches more.

But as Dr. *Becher* had the opportunity of employing a quick-silver-apparatus, and as, therefore, I have the less reason to doubt the exactness of his experiments, we are, from thence, the more confirmed in the supposition, that the proportion of the constituent parts of mineral waters is not every year, and, perhaps, not every day and hour exactly the same, but rather variable. This fact is also proved by other phenomena and arguments.

The water of Carlsbad, likewise, contains some *iron*, the presence of which can be ascertained only at the spring itself;  
since



since the quantity which actually exists in that fluid is so exceedingly small as to escape, in a most rapid and unexpected manner, the senses as well as the efficacy of re-agents. And, for this reason, many persons have absolutely doubted the presence of dissolved iron in these springs. But that they contain it, Dr. *Becher* has demonstrated by the following experiment. He suspended, by a thread, one half of a nut-gall in a glass bottle of a narrow neck, and filled the vessel on the very spot with water of the main-spring. As soon as the water, in the action of filling, came in contact with the nut-gall, it acquired a reddish colour; but five minutes after, the colour changed to a bright-red, inclining to the violet.

We, likewise, made the same experiment. Having previously suspended a slice of a gall, by means of a white silk thread, in a glass-bottle, of 50 cubic inches capacity, we filled it at the main spring. The water instantaneously turned of a pale red; but after having stood at rest, for one hour, a purple-red, extremely light, woolly, flocculent sediment subsided, which left the superincumbent liquor clear and colourless.

Another bottle, in which one grain of pulverized pure Prussian alkali had been placed, when likewise filled at the spring itself, shewed no change or indication of colour. But some minutes after, when we instilled some drops of nitric acid to saturate the predominant soda, the blue colour appeared by degrees; so that, at length, the water was uniformly tinged blue by it.

The following experiments convinced us, how necessary it is to perform these trials at the spring itself. We had ordered a jug, recently filled, at the main-spring, and closely stopped, to be brought to our lodgings; where we immedi-



ately, and before the temperature of the water had been sensibly lowered, examined it by means of galls, and tincture of galls. But it remained for a while colourless; only, by degrees, it inclined a little to a feeble, turbid olive-green; and when afterwards a few drops of nitric acid had been added, the colour passed into a shade of a dilute blueish-black.

But when the water from the main-spring had cooled more considerably, it was no more possible to produce, by any means, any change of colour, or indication of iron.

The water of the *new spring* afforded the same phenomena as that of the main-spring; that is to say, when the bottle, into which the re-agents had been previously introduced, was filled at the spring itself, the water became coloured, and shewed its ferruginous contents. But when conveyed to our apartment, in well closed bottles, it was tinged in some degree, while its original temperature continued; but as soon as the water began to cool, no trace of colour could then be any longer discovered.

On the contrary, the water from the *spring at the castle*, though likewise taken at the spring itself, and there examined, suffered no change at all.

It now remained to investigate the other *fixed* constituent parts: for this purpose, we gradually evaporated, with a gentle heat, *one hundred* cubic inches of water, freshly taken from each of those three springs, down to some ounces.

We then separated, by means of filtration, from these residues, thus reduced by evaporation, the *earthy* parts from the *saline*, that were yet held in solution by the water, and washed and dried them. This earthly portion consisted of *carbonated lime*, mixed with *siliceous earth*, and a slight trace of  
of



of iron. By digesting it with muriatic acid, the lime and the iron dissolved, and, on the filter, we obtained the flex alone, in a loose, slimy state. The muriatic solution we treated, at first, with prussiat of pot-ash, and there immediately appeared blue flocculent particles: however, it was only after some days that they formed a solid precipitate. When the supernatant liquors had again become clear and colourless, and the precipitate had been separated upon the filter, we precipitated the calcareous earth from each of them by carbonated ammoniac,edulcorated, and dried it.

We now proceeded to separate the salts combined in those solutions. Taught by experience, that heterogeneous salts, existing in one common menstruum, can but seldom be separated, by crystallization, with due accuracy, especially in small experiments, we adopted another more certain method; namely, by saturating, first, the uncombined soda by an acid, and decomposing afterwards the neutral salts by proper substances. At the same time, by other previous experiments, we had discovered and ascertained the proportions of the ingredients in salts of the same nature, to be enabled thereby to calculate those results.

These last mentioned experiments, serving as standard measures in the present pursuit, were principally as follows.

a) *Thousand* grains of soda, recently crystallized and weighed, after drying on printing-paper, lost, when completely desiccated on the sand-bath, 637 grains of weight. Thousand parts of soda in the state of crystallization, therefore, are equal to 363 parts of the same alkali, reduced to a powder by a thorough exsiccation effected by means of heat.

b) *Hundred* grains of the same soda, deprived by heat of its water of crystallization, required, for their saturation,

382 grains of sulphuric acid, composed of a mixture of one part of that acid, rectified, and of 1,850 specific gravity, with three parts of distilled water.

c) The fulphat of soda, obtained by this saturation, and completely dried, by evaporating in a sand heat, weighed  $132\frac{1}{2}$  grains.

d) One *thousand* grains of fulphat of soda, recently crystallized and dried on printing-paper, when exsiccated to the most in a sand-heat, weighed 420 grains.

e) *Hundred* grains of the above-mentioned glauber-salt, dissolved in water, and decomposed by an acetic solution of barytes, gave 168 grains of washed and dried fulphat of barytes, or regenerated ponderous spar. Thousand parts of the latter, therefore, contain a portion of *sulphuric acid* equal to  $595\frac{1}{4}$  of fulphated soda, that has been deprived by heat of its water of crystallization.

f) One *hundred* grains of common salt in crystals, dried in the air, dissolved in water, and decomposed by a nitric solution of silver, yielded  $233\frac{1}{2}$  grains of edulcorated and dried muriat of silver, or precipitated hornsilver, as it is called. Whence the quantity of muriatic acid, contained in 1000 parts of this salt, is equal to  $428\frac{1}{4}$  parts of pure and dry muriat of soda.

Assisted by these discoveries, we could now, with certainty, expect the success of our attempt without danger of error, by making a proper use of them. Thus we first investigated the quantity of free or *carbonated soda*, by adding to every one of those solutions as much of an accurately weighed quantity of sulphuric acid, of the specific gravity mentioned, (b) as was necessary to a complete saturation,  
and



and from the portions of the acid employed in these processes, we computed the quantity of the alkali contained in each of the solutions.

This done, we combined the muriatic solutions with dissolved acetate of barytes, until all precipitation ceased. From the weight of the *barytic sulphat* then generated, we calculated the quantity of sulphated soda: having, before, subtracted that portion of it, which had been produced by the saturation of the uncombined soda, and united with the glauber-salt, naturally contained in the spring.

At last, we decomposed the common salt, left in the solutions after the separation of the barytic sulphat, by means of a nitrated solution of silver; and we computed the quantity of that muriated soda from the hornsilver, obtained by the process.

It resulted from these experiments, that

A) *Hundred cubic inches of water from the main-spring, at Carlsbad, contain:*

|                                                  |                      |
|--------------------------------------------------|----------------------|
| <i>Dry carbonated soda</i> . . . . .             | 39 grains.           |
| (or, in crystalline state, $107\frac{1}{2}$ gr.) |                      |
| <i>Dry native sulphat of soda</i> . . . . .      | $70\frac{1}{2}$      |
| (or, in crystals, 168 gr.)                       |                      |
| <i>Muriat of soda</i> . . . . .                  | $34\frac{1}{2}$      |
| <i>Carbonat of lime</i> . . . . .                | 12                   |
| <i>Silex</i> . . . . .                           | $2\frac{1}{2}$       |
| <i>Oxyd of iron, about</i> . . . . .             | $\frac{1}{8}$        |
| <hr/>                                            |                      |
| Total . . .                                      | $158\frac{1}{4}$ gr. |

*Carbonic acid gas, 32 cubic inches.*

B)

B) *Hundred cubic inches of the water, taken from the new-spring, contain:*

|                                            |                          |
|--------------------------------------------|--------------------------|
| <i>Dry Carbonat of soda</i> . . . . .      | $38\frac{1}{2}$ grains.  |
| (or, crytallized, 106 gr.)                 |                          |
| <i>Dry native sulphated soda</i> . . . . . | $66\frac{3}{4}$          |
| (or, crytallized, 159 gr.)                 |                          |
| <i>Muriat of soda</i> . . . . .            | $32\frac{1}{2}$          |
| <i>Carbonat of lime</i> . . . . .          | $12\frac{3}{8}$          |
| <i>Siliceous earth</i> . . . . .           | $2\frac{1}{4}$           |
| <i>Oxyd of iron, hardly</i> . . . . .      | $\frac{1}{8}$            |
| <hr/>                                      |                          |
| Total . . .                                | $152\frac{1}{2}$ grains. |

*Carbonic acid gas, 50 cubic inches.*

C) And lastly, an *hundred cubic inches of water from the spring at the castle yielded,*

|                                        |                           |
|----------------------------------------|---------------------------|
| <i>Dry carbonat of soda</i> . . . . .  | $37\frac{1}{2}$ grains.   |
| (or, in crytals, $103\frac{1}{2}$ gr.) |                           |
| <i>Dry sulphated soda</i> . . . . .    | $66\frac{1}{2}$           |
| (or, in crytals, $158\frac{1}{2}$ gr.) |                           |
| <i>Muriat of soda</i> . . . . .        | 33                        |
| <i>Carbonat of Lime</i> . . . . .      | $12\frac{3}{4}$           |
| <i>Silex</i> . . . . .                 | $2\frac{1}{8}$            |
| <i>Oxyd of iron, hardly</i> . . . . .  | $\frac{1}{16}$            |
| <hr/>                                  |                           |
| Total . . .                            | $151\frac{1}{16}$ grains. |

*Carbonic acid gas, 53 cubic inches.*

In order to enable any person to reduce these constituent parts to certain weights, or to other liquid measures of the mineral water, I will mention, that the cubic inch, which, in these



these experiments, has been made the standard, is equivalent to 290 grains of distilled water, (of the genuine medicinal weight of Nurenberg \*). The above 100 cubic inches, therefore, with respect to their solid capacity, are equal to  $60\frac{5}{12}$  ounces of water.

On comparing the fixed constituent parts, discovered by Count *Gefslor* and *myself*, with those given by Dr. *Becher*, I shall notice merely the water of the main-spring. The quantity of it, which he employed, in every instance, was six pounds medicinal weight. Dr. *Becher* observes, that he means the old apothecary's weight and measures, formerly used there; which is, to that now introduced, as 12 to 14; but I suppose that the above is the same with the usual medicinal weight, of 12 ounces, or 5760 grains. Therefore, by calculating, according to these data, the dry residue which we should have obtained from 6 lb. medicinal weight, or from  $119\frac{5}{8}$  cubic inches of water from the main-spring, would have amounted to  $189\frac{27}{32}$  grains; and this very nearly agrees with the 192 grains obtained by Dr. B.; the difference of  $2\frac{1}{32}$  being very unimportant, especially as he himself has also obtained three drachms, or 180 grains less of this dry residue from an equal quantity of the main-spring water. With regard to the *proportion* of the fixed parts to one another, Dr. *Becher* thinks that the several constituent ingredients, in those 192 grains, may be divided in the following manner:

|                            |                 |
|----------------------------|-----------------|
| Dry soda . . . . .         | 53 grains.      |
| — Sulphat of soda . . . .  | 93              |
| Muriat of soda . . . . .   | 26              |
| Calcareous earth . . . . . | $20\frac{1}{2}$ |

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\* Or  $278\frac{1}{4}$  grains, *English* Troy, very nearly. Transl.

But,

But, according to the result of our experiments, the above-mentioned 192 grains of the residue of the water from the main-spring would afford,

|                                    |                          |
|------------------------------------|--------------------------|
| <i>Dried soda</i> . . . . .        | 47 $\frac{1}{4}$ grains. |
| — <i>Sulphat of soda</i> . . . . . | 85 $\frac{1}{4}$         |
| <i>Muriat of soda</i> . . . . .    | 42                       |
| <i>Calcareous earth</i> . . . . .  | 14 $\frac{1}{2}$         |
| <i>Siliceous earth</i> . . . . .   | 3                        |

To explain these variations, besides first repeating the observation before mentioned, that in mineral waters the proportion of the ingredients is not, at all times, invariably the same, I believe the following remark may be of some assistance in elucidating the difference.

a) Dr. *Becher* procured the *soda*, which he used in his preparatory experiment, by dissolving, in water, the calcined residue of the desiccated mother-water; and, having crystallized it, he considered the salt obtained, at the third shooting, as pure mineral alkali, and employed it accordingly. This, however, cannot easily be presumed to have been perfectly pure, but was probably still mixed with some common salt; which supposition seems to be strengthened by the figure of the crystals, described as minute-grained and needle-shaped. On every account it would, indeed, have been not superfluous to have tried, before-hand, by experiments, the purity of the soda, and the total absence of all neutral saline admixtures. For, in proportion as the soda employed in the comparative experiment was still rendered impure, by any foreign salt, in the same ratio must the calculation, founded upon it, have given an excess of soda above the true quantity which enters into the water of the spring.

b) That the portion of *common salt* was found to be much less by Dr. *Becher*, than by us, arises from the uncertain



method which he has employed to separate the fulphat and muriat of soda, by mere crySTALLIZATION; since the former, especially in the last shootings, always attracts to itself a portion of the latter, which accompanies it in the lye. Therefore,

c) The proportion of the *neutral fulphat* of the spring, as determined by calculation, must, for the same reason, have appeared greater than it really is.

d) The *siliceous* ingredient in the water of Carlsbad has entirely escaped the attention of Dr. *Becher*, as it did other authors, who treat of this spring. This, however, may be excused, because *silice* has been formerly considered as a substance totally insoluble in water, and, therefore, has never been suspected to be a constituent part of mineral springs. But it cannot be allowed that this earth is only casually admixed with the water, and floats in it as a fine sand; for, that it exists in it in an actual state of solution, is evident, from the swelled, slimy, and transparent state in which it remains after the solution of the calcareous earth.

Nevertheless, this quantity of siliceous earth, in Carlsbad water, whose solvent power over this earth is aided by its temperature, great as it may appear, with regard to other mineral springs, is, in fact, but inconsiderable, when compared with the *silice*, contained in a much larger portion, in other hot-springs; the *Geyser*, for instance, in *Iceland*. But it must also be observed, that the temperature of this last so far exceeds that of Carlsbad, that, according to *Troil's* testimony, even when this immense jet of 19 feet in diameter had risen, as it often does, to the height of 90 feet, its water is still found perfectly boiling hot, when it again comes down to the ground.

I shall

I shall now give an estimate of the quantities of the constituent parts of the water of Carlsbad, taken by its visitors. The mean number of cups which are drank is 14 in the day, as the daily allowance is from 10 to 18; the immoderate quantity of 30 or 40 cups, and upwards, which were formerly taken, being now laid aside: one of these cups, upon an average, holds nearly 10 cubic inches of water; and, therefore, will hold 140 cubic inches, which contain:

|                                     |             |                           |
|-------------------------------------|-------------|---------------------------|
| <i>Crystallized carbonated soda</i> | . .         | 150 $\frac{1}{2}$ grains. |
| <hr/> Sulphat of soda               | . .         | 228                       |
| <i>Muriat of soda</i>               | . . . , . . | 48                        |
| <i>Calcareous earth</i>             | . . . . .   | 17 $\frac{1}{2}$          |
| <i>Siliceous earth</i>              | . . . . .   | 3 $\frac{1}{2}$           |
| <i>Oxyd of iron</i>                 | . . . . .   | $\frac{1}{4}$             |

*Carbonic acid gas*, 45 cubic inches.

The time usually spent in the medicinal use of this spring is from three to five weeks. If, therefore, we assume, at a mean rate, 26 days for the whole of that time, and calculate by it the quantity of water drank by each patient, it will be found to amount to 364 cups, holding 3640 cubic inches of the mineral water, which contain,

|                                      |           |                 |
|--------------------------------------|-----------|-----------------|
| <i>Crystallized carbonat of soda</i> | . .       | 3913 grains.    |
| <hr/> sulphat of soda                | . .       | 5928            |
| <i>Muriated soda</i>                 | . . . . . | 1248            |
| <i>Calcareous earth</i>              | . . . . . | 450             |
| <i>Siliceous earth</i>               | . . . . . | 91              |
| <i>Oxyd of iron</i>                  | . . . . . | 6 $\frac{1}{2}$ |

*Carbonic acid gas*, 1170 cubic inches.

It is not my province to speak of the medicinal effects of the mineral spring at Carlsbad. On this subject various cele-



celebrated physicians and writers, as *Fred. Hoffmann*, *Tralles*, *Springsfeld*, *Zückert*, and in particular *Dr. Becher*, the respectable author of the above-mentioned *Description of Carlsbad*, have given sufficient information and instruction.

On one point, however, I shall briefly touch. Many persons, less versed in chemistry, are of opinion, that the native glauber-salt of this mineral spring is essentially different from, and preferable to any other sulphat of soda; upon the ground, that a moderate quantity of the water, for instance 14 cups, in which that neutral salt, calculated in the crystalline state, amounts only to 228 grains, or 12 grains less than half an ounce, is found to possess a greater aperient power than any other artificial glauber-salt, though taken in greater proportion. But in this statement, which is confirmed by experience, we should not forget to have due regard to the influence of the soda; because the alkaline substances and earths are converted into neutral or middle salts, in the stomach and first passages, whenever, as is mostly the case, any acid there predominates, and they thus acquire the cathartic properties of other purging salts. Nay, it is probable that it is owing to this constituent part of the Carlsbad water that several persons, whose humours in the stomach and first passages are, perhaps, more disposed to *alkalescence* than *acidity*, often experience, on its internal use, effects quite contrary to those which they expected from its opening power. Moreover, the siliceous ingredient may be frequently an accessory cause of the unpleasant effects on the bowels, which the water produces in those persons in whom the *peristaltic motion* is rather languid.

However, these, as well as all other medical remarks, I leave to the physicians, and will allow to myself only some reflections concerning the substances, which Nature employs to impregnate the Carlsbad mineral spring with the above-

mentioned ingredients, and concerning the manner in which, perhaps, it operates in this process. I say, *perhaps*, for the searching mind of man is not endowed with the faculty of inspecting the interior and secret recesses of the laboratory of Nature, without danger of error. All that we are able to do, is to suspect, and to draw probable conjectures from phenomena similar to those, which we have had opportunity of perceiving either in the operations of Nature herself, or in our small chemical experiments.

The cause which produces the heat in the springs at Carlsbad is variously stated by philosophers. The opinion of a great fire, supposed to exist in the centre of the globe, to which, formerly, all the great phenomena in the subterraneous laboratory of Nature, and hence also the generation of hot mineral springs, have been ascribed, has, at present, scarcely any supporter. Others would account for that cause by the volcanos, which are said to have once existed in that country, and, though burned out on the surface, are not yet perfectly extinguished beneath. But this, likewise, is an ill-founded hypothesis; as neither a true crater, nor what might have once been the fire-gulph of a volcano, nor any undoubted lavas and other matters ejected from it, can be found there. In fact, the earthy scoræ, met with in the vicinity of Carlsbad are not of a true volcanic origin; and as little may the basalts, which are there met with, be considered as an additional proof of the volcanic nature of that country.

Those naturalists seem to come nearer to truth, who trace the efficient cause of heat in these springs from ignited sulphur-pyrites. With this opinion, likewise, the celebrated author of the *Treatise on Carlsbad Water* coincides, when explaining the temperature of its springs. And, indeed, it cannot be denied, that pyrites act their part in this case.

For



For the stratum of pyrites, which is only a few miles distant from Carlsbad, and from which the sulphur and vitriol-works at *Altsattel* are plentifully provided with that crude material; besides, the siliceous ingredient disseminated in the stony mixture of that stratum, under which, according to all indications, that subterraneous laboratory lies where Nature prepares the mineral water; and, lastly, those constituent parts of these mineral springs, the origin of which we cannot explain from other substances besides from sulphur-pyrites: all these circumstances coincide to give weight to that opinion.

Yet, on a maturer consideration, it will soon be evident, that the dissolved pyrites could not alone afford that quantity of caloric, which has heated the springs at Carlsbad, for several centuries past to this day, with unabated force; but, on the contrary, that, to the production and preservation of natural hot springs in general, another combustible matter is required, from which the subterraneous fire receives its food. And thus it will be obvious, that this fuel can be nothing else but mineral coal, that remainder of vegetable fragments of the ancient world, locked up in the bosom of the earth, which provident Nature has wisely reserved.

When a subterraneous store of mineral coal, such as occur in various places in strata, of an enormous thickness, has been once set on fire, by ignited pyrites or other causes (as may easily happen, especially where the stratum comes out near to the day) the inflammation will then spread throughout the whole remaining mass, with a quicker or slower progress. A spontaneous extinction and complete refrigeration can certainly not be very soon expected in that case; for the larger the bulk of a burning body is, the longer will the heat, excited by it, continue. If, besides, it is considered, that this immense mass may possibly be inclosed by walls of  
v 2 rocks,



rocks, impenetrable, and little capable of conducting heat, at the same time that the air finds access to it in but a very small degree; it is then easy to conceive, that ages must pass before the caloric disengaged from such an immense mass can be fixed again, and brought to a state of equilibrium with the whole.

But that a mine of mineral coal had once been burning at Carlsbad is a fact, unquestionably proved by the earthy scoræ that have been erroneously taken for genuine volcanic lavas, by the porcelain-jaspers, and by the other species of stones and earths, more or less changed by fire, covering the fields at *Hobdorf*, *Leffa*, and other places, in copious quantity, many of which perfectly resemble the pseudo-volcanic products of various countries; such, for instance, as the stratum of mineral coal even now burning at *Duttweiler*, near *Saarbrück*.

*Carlsbad*, which is situated in a narrow, longish valley, is on all sides surrounded by mountains of the middle size; which, however, little cohere among themselves. These mostly consist of granites, of which that variety is the most predominant, which consists of much, large, yellowish, white rhombic fel-spar, with small black micaceous scales, and a little fine grained quartz.

But, close to the *Hirschenstein*, the highest of those mountains, and situated south of the town, there stretches from the *Guldball* to the *Bernhards-rock* another range of low mountains, which cannot properly be considered as primitive granite, but rather as a rock of later formation: since it exhibits a stony mass, a second time formed of fragments of the primeval rock, and consisting of a granitic mass of stones, finely grained and rifted, passing into a porphyreous mixture, with finely interspersed pyrites. It is the  
common



common opinion, which is also supported by various local circumstances, that underneath this mountainous range, the laboratory lies, where Nature produces that beneficial spring. For, not only does the vaulted roof of the basin, or reservoir of the main-spring, (the breadth of which extends from the Guildhall, along and under the market-place, as well as under the bed of the river *Töpel*, to the church) proceed from the foot of that low rock, but also all the other springs issue from it; besides, that the warm mineral water oozes out from several other of its fissures and veins. But, if this stony matter is granted to be of secondary formation, and not a primitive rock, the possibility of a mighty stratum of mineral coal, lying under it, can no longer be questioned.

Now, concerning the generation and origin of those constituent parts, with which this hot water is impregnated, and thereby ennobled to the rank of a medicinal spring; these depend on the *very same laws of nature*, which chemistry has learnt by experiments to be such, and by which it is guided in imitating the operations of Nature in the small way. Yet, our knowledge, it must be confessed, is not always sufficient to comprehend, accurately and distinctly, the method which Nature employs in every particular instance. Nature, in her great operations, always proceeds in a simple way; whereas, we being but humble imitators of that great mistress of chemistry, cannot help resorting to artificial, and thence imperfect processes, whenever we attempt to obtain the same products from the same principles.

First, as to the origin of the *carbonic acid* in the water of Carlsbad, the opinion of the author of the *Neue Bemerkungen über das Carlsbad*, who deduces the gas of that spring from the sulphur-pyrites themselves, cannot subsist;

for, what is extricated from mouldering pyrites is not the carbonic, but the *fulphureous acid*, combined, according to circumstances, with *hydrogen gas*. On the contrary, it admits of no doubt, but that *limestone* is the principle, which in all cases, and hence in this also, affords the carbonic acid. From the fact already related, that the rock seated upon the laboratory of this spring is of a younger date, and later formation; it is certain that limestone may be present at some depth; whether it consist of primitive calcareous rock, or of stratified calcareous stones; and that it actually and necessarily there exists, is manifest from this very daily generation of so great a quantity of carbonic acid. But, whether the developement of this elastic acid from the limestone is effected merely by the heat, or by means of the sulphuric acid, disengaged from the dissolved pyrites, is a question which cannot be *positively* answered. It is, however, probable, that it is expelled by heat alone.

With regard to the generation of the *neutral sulphat*, or the *glauber-salt*, it undoubtedly cannot take place, but when veins of common salt come into contract with dissolved sulphur-pyrites. Part of the muriated soda is then decomposed by the sulphuric acid, and unites with it to a new neutral salt, *viz.* the native glauber-salt, or sulphat of soda.

And, as the existence of carbonic acid in the Carlsbad water necessarily presupposes the presence of a calcareous stratum; the enquiry into the origin of the calcareous earth, dissolved in this mineral spring, is answered of itself. It is by the spontaneous separation of that earth from the water, that the above-mentioned wonderful stone-vault, of the great reservoir, together with the remaining vast quantity of variously formed stalactites and tufas, have been produced, and are daily augmented. Therefore, it is not necessary to search in vain, with Dr. *Becher*, and against all rules,



rules, for the origin of the calcareous earth in the mixture of the pyrites; nor to lay any stress on the small quantity, which might be an accidental ingredient in the muriated brine, employed by Nature in the production of the mineral springs at Carlsbad.

But we cannot judge with equal certainty of the method followed by Nature, in generating the uncombined soda existing in the Carlsbad water; since, of all the methods, which we are able to employ for the same purpose, there is none of such a kind that we could fairly suppose to be applied in the operations of Nature, who always accomplishes her ends by the shortest ways. It is probable that a long continued influence of the subterraneous heat, and humid vapours, are alone sufficient to volatilize part of the muriatic acid of the muriated soda, leaving behind the alkaline principle that had been united with it.

On this predominant portion of free soda also depends in part the peculiar taste of Carlsbad water, which, when drank warm, may be compared to a weak meat-broth.

*Sulphur-pyrites, mineral coal, limestone, and brine-springs of muriated soda,* are, therefore, the raw materials made use of by Nature in elaborating those hot mineral springs. How enormous the store of them must be, may be conceived by reflecting upon the quantity of water, and its ingredients, which is afforded by the *main-spring* alone, in the course of one year. By the computations of *Dr. Becher*, there issue 705 *eimers* in an hour, from the five orifices of that spring; which makes, for one day, 16,920; and hence, for the year, 6,175,800 *eimers*. And, if the *eimer* be taken to be equal to *one half cubic foot*, that quantity amounts to 3,087,900 cubic feet of water. These contain:

|                                        | <i>Pounds avardupoise.</i> |
|----------------------------------------|----------------------------|
| <i>Crystallizable soda</i> . . . . .   | 746,884                    |
| ————— <i>fulphat of soda</i> . . . . . | 1,132,923                  |
| <i>Muriat of soda</i> . . . . .        | 238,209                    |
| <i>Calcareous earth</i> . . . . .      | 86,020                     |
| <i>Siliceous earth</i> . . . . .       | 17,369                     |
| <i>Oxyd of iron</i> . . . . .          | 1,240                      |

*Carbonic acid gas* 992,539 cubic feet.

And, since the quantity of water yielded by the *new-spring*, by that *at the mill*, and by the *other streamlets* issuing from the clefts of the rifted rock, taken together, may be estimated as equal to that afforded solely by the main-spring; our astonishment is justly excited, on considering the immense quantity of products which have been sent forth by those springs at Carlsbad, within a term of 420 years; that is, from 1370, which is the period assumed in history for their discovery, to 1790.

Yet, no other use is made of the great quantity of saline contents with which Nature has enriched the Carlsbad-mineral springs; except, that yearly, several hundred pounds of sulphated soda are obtained in the crystallized state, by evaporation, and sold by the name of *Carlsbad-salt*. But it would be an object, deserving the exertions of industry, if, at the same time, pains were taken to recover and employ one part of mineral alkali, or soda; instead of suffering so many thousand pounds of that natural product, so valuable with respect to our present wants, to be unemployed, and carried away into the river *Töpel*.

Before I conclude, I shall say a few words on a cold *acidulous spring*, which is met with behind the brew-house, in a granitic rock. This spring collects in a small shallow basin, situated on the declivity of the rock, and is richly impreg-



impregnated with carbonic acid, that penetrates through the bottom of the basin, and covers the fluid in a stratum from four to six inches thick. Its taste is so exceedingly sour, that a doubt has arisen, whether that acidity depends merely on the proportion of the carbonic acid. But experiments have shewn it to contain no other extraneous acid; and the quantity of carbonic acid gas was found to be equal in volume to that of the water itself, where 18 cubic inches of water have yielded 18 cubic inches of the gas. This *acidulous spring* hardly contains any fixed constituent ingredients: for, when a considerable quantity of it has been evaporated by the assistance of heat, a residue was indeed left, which proved to be a neutral muriat, but so small, as almost to escape observation.

This valuable, but, at Carlsbad, little esteemed spring, methinks, deserves to be protected against the casual impurities by which it is now liable to be defiled, by a more suitable inclosure and careful covering; as well as to be more commonly applied, both for *medicinal* and *economical* purposes.

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## XXVI.

## CHEMICAL EXAMINATION

OF THE

*SALT-SPRINGS AT KÖNIGSBORN,**And their Products\*.*

THE saline springs, among others, chiefly belong to those objects, with the investigation of which the industry of chemists has been hitherto but little occupied. This want of a more solid and complete knowledge of the constituent parts of the saline springs cannot fail to have occasioned a number of erroneous processes in the salt-works; and, the necessity of abolishing or correcting them, is in general suggested only by the loss experienced for many years. How many errors would have been avoided in the calculations and estimates, if, for instance, instead of employing the *hydrometer*, that deceitful, empirical scale, which hitherto has been almost alone resorted to, and trusted, in ascertaining the proportion of salt contained in any brine, the salt-makers had been able to proceed upon the ground of a more certain knowledge, founded on chemical analysis, of the true saline portion, as well as of the other foreign substances, which are the habitual concomitants of common salt? For this reason, I believe, that by publishing the present inquiry into the saline springs, and their various products, of the *salt-works* at *Königsborn*, near *Unna*,

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\* *Sammlung der Deutschen Abhandlungen der Königlichen Academie der Wissenschaften.* Berlin, 1794.



in *Westphalia*, I am contributing, perhaps, not an unimportant share to a general chemical knowledge of saline springs.

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The saliniferous mountain at *Königsborn* consists of a compact, marly limestone, separated in strata, and disintegrable in the air, which seem to rest immediately upon the sand-stone, or red *dead rock* \*. They extend in a direction from east to west, from *Paderborn*, between the river *Lippe* and *Emsche*, as far as the dukedom of *Cleves*; and they decline, from south-west to north-west, into the bishopric of *Münster*, where they are covered by strata of sand and loam. The salt-springs at *Salzlotten*, *Westringotte*, *Werle*, *Saffendorf*, and *Unna*, which have been used for many centuries past, and several indications of a weak brine, near *Bochum*, in the *Dortmundt* territory, &c. are likewise situated on the same mountains.

The present salt-work at *Königsborn* lies about one mile (English) distant from *Unna*, to the north, in a plain; accompanied on both sides by gentle elevations. Wherever the ground is perforated or dug, at and below *Königsborn*, towards the north, there are always salt-springs found; but above *Königsborn*, southwards, springs of sweet water exist, which come forth to the day, and even will rise in pipes to 10 or 12 feet. On this account, the brine has been procured, for many years past, by means of such perfora-

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\* By the *dead rock* is understood the stone, or substance, which lies between the primary and secondary strata, and participates of the nature of both. The Germans call it *tott-liegendes*; *Kirwan* calls it *semiprotolite*, and likewise *deadlier*. See his *Geological Essays*. Lond. 1799. page 225; and his *Elements of Mineralogy*. Lond. 1794. vol. i. page 363.—Transl.



tions, of which there have been more than twenty, of a depth from 75 to 280 feet. The brine obtained from these, at a depth from 50 to 80 feet, always contains from  $1\frac{1}{2}$  to two ounces of salt in the pound; that from 80 to 120 feet, contains  $2\frac{1}{4}$  ounces; but that from 120 to 200 feet, affords  $3\frac{1}{4}$ , and even  $3\frac{1}{2}$  ounces; and it is pumped up to the height of 12 feet above the surface, by means of the above-mentioned wooden pipes, in a quantity amounting to from three to four cubic feet every minute. Experience has shewn, that this saline spring has decreased in dry weather, in quantity of water, and richness of salt; but has increased, in both respects, in wet weather, or when in the midst of summer it has rained only a few days, after a great drought. However, after the lapse of four or six years, the brine has been so much impoverished, at every well, as to yield only  $1\frac{1}{2}$  ounce of salt; although neither the quantity flowing out had increased, nor had the brine been otherwise altered. As often, therefore, as this happened, a new perforation has been made, by which means a brine, 3 or  $3\frac{1}{4}$  ounces, rich in salt, was again obtained for some time. From this account it would seem, that there exist three distinct salt-springs lying upon each other; that the deepest are the richest; which, therefore, by their rising, force away the upper and lighter ones; and, that these last must be in conjunction with some stream, the sweet water of which washes a mass of salt, and thereby becomes impregnated with part of it. Hence may be explained the rapid increase of the quantity of the fluid, and of its proportion of salt, after rainy weather. In consequence of this conjecture, some years ago, shafts were sunk between the several borings; the lighter springs were stopped up, and the richest were brought out to the day. However, the event was, that by means of this perforation, at the 111th foot in depth, a copious spring was come at, but only one ounce in richness; which poured into the well, that was already 60 feet deep,



deep, in such quantities, that at every minute 25 cubic feet were to be overcome. On the very day that this spring had been pierced, the saline contents in the several brines augmented in all the wells, from  $1\frac{1}{4}$  ounce to  $1\frac{1}{2}$ , 2, and even  $2\frac{1}{4}$  ounces. This weak brine, therefore, seems to impoverish the richer ones, by penetrating through the fissures of the marly rock to the perforated cavities; and either keeping off the deeper springs of 3 ounces richness in salt, or mixing with, and thus lowering them down to 1 and  $1\frac{1}{2}$  ounce.

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To shew what quantity of salt may be procured from these springs, I shall select the period of three years; namely, from the 1st of June, 1788, to the last of May, 1791. During that time were procured:

35,521,534 pounds.

This gives for one year:

11,850,511 $\frac{1}{3}$  pounds.

By taking into the calculation the loss occasioned by the *boiling*, which has been ascertained by actual experiment, as well as the loss arising from the *graduation*\*; which, by estimation, is reckoned at 37 *per cent*, there will be required of the brine, to obtain the above produce in each year:

336,069,731 pounds; or,  
4,972,748 $\frac{1}{3}$  cubic feet.

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\* In other words: from evaporating the brine by means of air, previous to their boilings, in particular buildings, called *graduating-houses*. Consult *Gren's Principles of Modern Chemistry*. Lond. 1800. vol. i. page 294.—Transl.

In speaking of the chemical examination of those springs, to avoid unnecessary repetitions, I shall only in general explain the method in which I have proceeded in this inquiry; and, with respect to each particular spring, &c. I shall merely state the result of my experiments:

1.) In order to determine the specific gravity of each brine, I measured 50 cubic inches (each equal to 290 grains of distilled water); weighed, and compared them with the weight of an equal quantity of distilled water.

2.) These 50 cubic inches of brine were then evaporated, in a sand-bath, to a dry residue, and the weight of it noted.

3.) These residues were then covered in cylindrical glass-vessels, with alcohol, and extracted by means of it during 24 hours, at a moderate temperature, and with repeated stirring.

4.) After the alcohol had been again separated by filtration, it was evaporated to dryness. Upon the residue left by it, fresh ardent spirit was affused, in such a quantity as was necessary to separate the small portion of common salt, which had united with the spirituous solution, at the first extraction. After this, the last alcohol was likewise evaporated, and the residue weighed.

5.) That portion which had been extracted by alcohol consisted of *muriat of lime*, mixed with a very trifling portion of *muriated magnesia*; the proportion of which last was determined in the following manner:—The residue, obtained by the evaporation of the alcohol, was dissolved in water, the solution heated, and the earth precipitated by soda. This earth, when washed, was combined with sulphuric acid, added in excess. After the mixture had stood  
for



for a while in a warm place, and the predominant acid had been again absorbed by carbonat of lime, which was added for this purpose, the liquor was freed from the selenite or gypsum then generated, and evaporated by a gentle heat. When the selenite, which still appeared, was again separated, and the liquor sufficiently reduced, the solution was exposed to spontaneous exhalation in the open air, and thus made to crystallize. The sulphat of magnesia, produced by this process, was redissolved in water, and decomposed by soda; upon which the magnesia, which separated, was saturated with muriatic acid, evaporated to dryness; and the weight of this muriated magnesia subtracted from the muriated lime.

6.) The desiccated muriat of soda, remaining after the separation of those deliquescent salts, by means of alkohol, was next dissolved in water, and filtered.

7.) The remainder on the filter consisted of *sulphat* and *carbonat of lime*; and in some, brines of *oxyd of iron*.—When weighed, it was treated with muriatic acid, and the selenite separated upon the filter. The filtered solution, when it appeared to contain a separable portion of iron, was combined with caustic ammoniac; and the oxyd of iron, which fell down as a brown flocculent precipitate, when collected by the filter and ignited, was weighed, and its weight reduced to that of carbonated iron.

8.) I combined the muriatic solution of No. 6 with carbonat of soda, assisted by heat, when a precipitate ensued, consisting of carbonated lime. The soda, employed for its precipitation, having thus been again neutralized by the muriatic acid, I treated this muriatic solution with muriated barytes. From the sulphat of barytes, obtained by this management, it was obvious that the calcareous earth precipitated,

precipitated, by the carbonated soda, from the dissolved muriat of soda, had been combined with sulphuric acid in the character of *selenite*. In like manner, it followed from the proportion, which the quantity of sulphuric acid bore to the calcareous earth, obtained in a state of combination with it, that the muriatic solution contained selenite only, and no glauber-salt, nor any other alkaline or earthy sulphat. The total absence of these last was also confirmed by this; that the dry salt gradually dissolved in a mixture of two parts of alcohol with one of water, which I affused upon it; and, that at last nothing but selenite remained.

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The experiments, performed in the manner here explained, gave the following results:

## A.

*Brine of the Varsthauser-spring.*

Its specific gravity was 1039 (distilled water being 1000).

Fifty cubic inches, evaporated to dryness, afforded a grey-white residue, weighing 882 grains.

This residue consisted of:

|                                         |            |
|-----------------------------------------|------------|
| <i>Muriat of lime</i> . . . .           | 46 grains. |
| — <i>magnesia</i> . . . .               | 1          |
| <i>Carbonat of lime</i> . . . .         | 12         |
| <i>Selenite, or sulphat of lime</i> . . | 25         |
| <i>Muriat of soda</i> . . . .           | 798        |
|                                         | <hr/> 882  |

## B.



## B.

*Brine of the Glückauf-spring.*

Its specific gravity was found to be 1029.

Fifty cubic inches left a pale-red residue of 585 grains, containing :

|                                       |            |
|---------------------------------------|------------|
| <i>Muriat of lime</i> . . . .         | 32 grains. |
| — <i>of magnesia</i> . . .            | 1          |
| <i>Carbonat of lime</i> . . . .       | 11         |
| <i>Carbonated oxyd of iron</i> .      | 1          |
| <i>Selenite</i> . . . . .             | 18         |
| <i>Muriat of soda, or common salt</i> | 522        |
|                                       | <hr/> 585  |

## C.

*Brine of the Frederic-anton-spring.*

Its specific gravity was 1025.

Fifty cubic inches left, by evaporation, 540 grains, of a light-reddish residue, consisting of :

|                                                    |                  |
|----------------------------------------------------|------------------|
| <i>Muriated lime</i> , including a scarcely ob-    | } 20 grains,     |
| servable trace of <i>muriated magnesia</i>         |                  |
| <i>Carbonated lime</i> , or crude calcareous earth | 11 $\frac{1}{2}$ |
| — <i>oxyd of iron</i> . . . . .                    | $\frac{1}{2}$    |
| <i>Selenite</i> , or gypsum . . . . .              | 14               |
| <i>Muriated soda</i> . . . . .                     | 494              |
|                                                    | <hr/> 540        |

## D.

*Brine of the Goldener Sonnen-spring.*

The specific gravity was 1024.

The dry residue, yielded by 50 cubic inches, had a light-grey-white colour, and weighed 521 grains. It was resolved into :

|                         |           |                   |
|-------------------------|-----------|-------------------|
| <i>Muriat of lime</i>   | . . . . . | 30 grains.        |
| <i>— of magnesia</i>    | . . . . . | $\frac{1}{2}$     |
| <i>Carbonat of lime</i> | . . . . . | 11                |
| <i>Selenite</i>         | . . . . . | 15                |
| <i>Muriat of soda</i>   | . . . . . | 464 $\frac{1}{2}$ |
|                         |           | <hr/>             |
|                         |           | 521               |

## E.

*Brine of the Ludwigs-springs.*

Its specific gravity 1023.

The light-reddish residue, from 50 cubic inches of the evaporated brine, weighed 508 grains, and contained :

|                                      |           |                   |
|--------------------------------------|-----------|-------------------|
| <i>Muriat of lime</i>                | . . . . . | 20 grains.        |
| <i>Carbonated lime</i>               | . . . . . | 10                |
| <i>— oxyd of iron</i>                | . . . . . | $\frac{1}{2}$     |
| <i>Selenite</i>                      | . . . . . | 13                |
| <i>Common salt, or muriated soda</i> | . . . . . | 464 $\frac{1}{2}$ |
|                                      |           | <hr/>             |
|                                      |           | 508               |



The brine, which is brought up from the various salt-springs, is conducted into one common reservoir, from which it is pumped to the top of the *graduating-houses*, where it is three times *graduated*.

## F.

*Brine of the first graduation.*

Its specific gravity rose to 1060. The residue from the evaporation of 50 cubic inches weighed 1285 grains; and consisted of :

|                                               |                |
|-----------------------------------------------|----------------|
| <i>Muriated lime</i> . . . . .                | 65 grains.     |
| — <i>magnesia</i> . . . . .                   | $1\frac{1}{2}$ |
| <i>Carbonated lime</i> , containing some iron | $4\frac{1}{2}$ |
| <i>Sulphated lime</i> , or selenite . . .     | 44             |
| <i>Muriated soda</i> . . . . .                | 1170           |
|                                               | <hr/>          |
|                                               | 1285           |

## G.

*Brine of the second graduation.*

Specific gravity 1076.

Fifty cubic inches, evaporated, gave a residue of 1615 grains. This was decomposed into :

|                                   |            |
|-----------------------------------|------------|
| <i>Muriat of lime</i> . . . . .   | 75 grains. |
| — <i>of magnesia</i> . . . . .    | 2          |
| <i>Carbonat of lime</i> . . . . . | 3          |
| <i>Selenite</i> . . . . .         | 48         |
| <i>Muriat of soda</i> . . . . .   | 1487       |
|                                   | <hr/>      |
|                                   | 1615       |

x 2

## H.

## H.

*Brine of the third graduation.*

Its specific gravity amounted to 1086.

Fifty cubic inches of it have left, upon evaporation, 1850 grains of a dry residue, containing :

|                                             |            |
|---------------------------------------------|------------|
| <i>Muriat of lime</i> . . . . .             | 82 grains. |
| — <i>of magnesia</i> . . . . .              | 3          |
| <i>Carbonat of lime</i> . . . . .           | 3          |
| <i>Sulphat of lime</i> (selenite) . . . . . | 52         |
| <i>Muriat of soda</i> (common salt) . . .   | 1710       |
|                                             | <hr/>      |
|                                             | 1850       |

The salt obtained by boiling from these *graduated* brines is of two sorts, of which the one is destined for *foreign*, and the other for *home* consumption. The *first* consists, for the most part, of considerably large, four-sided, hollow crystals, composed, in a funnel-like manner, of simple cubes of muriated soda. Such crystals are always formed on the surface of the brine, when they can evaporate without agitation. The *second* sort is externally distinguished from the preceding by somewhat smaller and less regular crystals.

## I.

*Common salt for exportation.*

One pound of it, that had been completely desiccated with the assistance of heat, was pulverized, and then



examined by the method above-described. It consisted of:

|                                                    | Oz. | drach. | gr. |
|----------------------------------------------------|-----|--------|-----|
| <i>Moisture</i> , expelled by the drying . . . . . | —   | 3      | —   |
| <i>Accidental impurities</i> , and sand . . . . .  | —   | —      | 10  |
| <i>Muriated lime</i> . . . . .                     | —   | —      | 25  |
| <i>Selenite</i> . . . . .                          | —   | 1      | 30  |
| <i>Pure muriat of soda</i> . . . . .               | 15  | 2      | 55  |
| <hr/>                                              |     |        |     |
| 16 Ounces.                                         |     |        |     |

K.

*Common salt for home-consumption.*

One pound of it, treated as the last, contained:

|                                        | Oz. | drach. | gr. |
|----------------------------------------|-----|--------|-----|
| <i>Moisture</i> . . . . .              | —   | 4      | 30  |
| <i>Accidental impurities</i> . . . . . | —   | —      | 18  |
| <i>Muriated lime</i> . . . . .         | —   | —      | 30  |
| <i>Selenite</i> . . . . .              | —   | 1      | 35  |
| <i>Pure muriat of soda</i> . . . . .   | 15  | —      | 7   |
| <hr/>                                  |     |        |     |
| 16 Ounces.                             |     |        |     |

L.

*Mother-water.*

The mother-brine proved to be of considerable specific gravity; namely, 1218.

Fifty cubic inches of it, when evaporated, yielded 5440 grains of dry salt, which I divided into two parts, subjecting each to a separate examination.

310 XXVI. Chemical Examination of the

1) 2720 grains, or one half of the salt obtained from the mother-water, and decomposed after the manner so often mentioned, gave :

|                                   |         |             |
|-----------------------------------|---------|-------------|
| <i>Muriated calcareous earth</i>  | . . . . | 330 grains. |
| ————— <i>magnesian earth</i>      | . . . . | 420         |
| <i>Sulphated calcareous earth</i> | . . . . | 50          |
| <i>Common salt</i>                | . . . . | 1920        |
|                                   |         | <hr/>       |
|                                   |         | 2720        |

2) The other half of the salt, afforded by 50 cubic inches of the mother-water, I re-dissolved in water, and evaporated the solution to the point of crystallization. I obtained from it, at five successive shootings, 4 ounces and 2 drachms of crystallized muriated soda, but which was still contaminated by the mother-water which adhered. For this reason, I dissolved it once more in water, and crystallized it anew ; By which treatment I then obtained 3 oz. 7 dr. of pure common salt. By this it was rendered evident, that every cubic foot of that mother-water, if treated in the simple way of crystallization, would still afford 16 or 17 pounds of pure muriat of soda. The mother-water of both crystallizations was diluted with water, and its earthy portion, precipitated by soda, weighed 544 grains, when washed and ignited. This precipitate consisted of *calcareous* and *magnesian* earth ; which I separated, by saturating the mass with sulphuric acid. When the sulphat of magnesia had been filtered off from the sulphat of lime which was formed at the same time, I decomposed it by means of soda. The magnesia, then obtained in a pure state, and weighing 290 grains, by treating it with muriatic acid, was converted into muriat of magnesia, which, evaporated to dryness, amounted to 420 grains ; exactly as it did in the foregoing process.



This portion of muriated magnesia, contained in the mother-water along with the muriated lime, and exceeding the latter in quantity, deserves particular notice. In both brines, in the *graduated* as well as the rough, the muriated magnesia amounted only to the 30th or 40th part of the muriated lime; in the mother-water, on the contrary, the quantity of the first exceeds the latter nearly by one fourth part. The cause of this seems to lie in the following circumstance:—It is customary, at Königsborn, to preserve the mother-water of 4, 5, or more boilings in the boiler. At any subsequent boiling, therefore, a stronger heat is required, to promote the crystallization of the salt; and when, in this case, a part of the bottom of the boiler becomes dry, a portion of the muriated lime is then decomposed, and its earthy basis becoming *free*, increases the calcareous earth in the *seblot*, or incrustation (*pfannenstein*) of the vessel: but the muriatic acid escapes in vapours, as may distinctly be perceived by the smell.

## M.

*Incrustation of the boiler.*

One Pound of it, pulverized and dried in a gentle heat, was boiled with 12 lb. of water. The filtered solution was next evaporated to dryness, and the salt obtained was treated in the method all along mentioned. When the undissolved, grey-white, earthy residue was examined, it proved to be a mingled mass of sulphat of lime, of carbonated lime containing a little iron, and of a sandy siliceous earth.

The proportion of these constituent parts to each other was found to be as follows:

x 4

Oz.

|                                                                                     | Oz. drach. gr. |   |            |
|-------------------------------------------------------------------------------------|----------------|---|------------|
| <i>Moisture</i> . . . . .                                                           | 1              | 6 | —          |
| <i>Muriated lime</i> . . . . .                                                      | —              | 1 | 10         |
| — <i>magnesia</i> . . . . .                                                         | —              | — | 10         |
| <i>Muriat of soda</i> , with a scarcely per-<br>ceivable trace of sulphated soda, } | 4              | 4 | 40         |
| <i>Carbonat of lime</i> . . . . .                                                   | 1              | 2 | 30         |
| <i>Sandy siliceous earth</i> . . . . .                                              | —              | 3 | 30         |
| <i>Sulphat of lime (selenite)</i> . . . .                                           | 7              | 6 | 0          |
|                                                                                     |                |   | 16 Ounces. |

N.

*Dornenstein.*

(That is, the earthy and saline incrustations formed on the brush-wood in the *graduating houses*.---Transl.)

The *Dornenstein* of these salt-works consists of a dark-brown, compact, indurated, stony crust, similar to the incrustations at *Carlsbad*.

1.) Of this I boiled *two ounces*, reduced to powder, with a sufficient quantity of water. This, however, would dissolve but little; for, after evaporation, there remained only four grains of common salt, mixed with iron and selenite.

2.) The powder of the stone which remained after boiling was saturated with muriatic acid. The solution was attended with great effervescence, and, towards the end, was promoted by heat. When filtered, it left selenite behind.

3.) This



3.) This muriatic solution, combined with caustic ammoniac, deposited a quantity of iron in a flocculent form; the weight of which, first ascertained when collected and ignited, was afterwards reduced to that of carbonated iron.

4.) The solution, now perfectly colourless, afforded carbonat of lime, by the addition of soda.

The proportion of the ingredients in these two ounces, or 960 grains of the mentioned *Dornenstein*, was :

|                                    |          |
|------------------------------------|----------|
| <i>Impure common salt</i> . . .    | 4 grains |
| <i>Selenite</i> . . . . .          | 25       |
| <i>Carbonated oxyd of iron</i> . . | 92       |
| ———— <i>calcareous earth</i> .     | 828      |
| <i>Moisture</i> . . . . .          | 11       |
|                                    | <hr/>    |
|                                    | 1960     |

What corrections, or improvements, might be made in the boiling of salt in the *salt-works* at *Königsborn*, in consequence of the analysis here communicated of the salt-brines, or springs of that place, and their products, I leave to the judgment of practical *balurgists*, or salt-makers.

But the advantage which the science may derive from the performance and collection of these and similar analyses, cannot be doubted : thereby, not only the sum of our observations hitherto collected, on the nature and constituent parts of salt-springs in general, will be rendered more complete and certain ; but likewise the knowledge of the laws of elective attractions of bodies, in particular, will be  
in-



increased and corrected. An instance of this last is afforded in the present analysis, by the circumstance that, in these salt-brines, no glauber-salt is found, but only selenite; although the latter, situated in the proportion in which it is contained in the mixture, should be decomposed according to the laws of affinities: at the same time that the soda of the common salt should combine with the sulphuric acid of the selenite, to form glauber-salt. But it must be here considered, that the agency of the attractive forces in bodies likewise depends on the various degrees of temperature: and this is really the case in this instance: for it is shewn, by experience, that the generation of sulphat of soda from the muriats of lime and soda, or, in other words, the generation of glauber-salt from selenite and common salt, can take place only at a cold, much below the point of freezing; but to such a low temperature the salt-springs are not exposed in their subterraneous reservoirs and canals. Whence it also happened, that when, with this view, I repeated the experiment with 16 ounces of the mass which incruited the boiler (*pfannenstein*), and which, during the winter, had been exposed to the cold, and had, in part, fallen to pieces, the newly-generated glauber-salt immediately appeared. Its quantity, ascertained by means of muriated barytes, and calculated for the crystalline state, did, however, in general, amount to no more than 36 grains.

Finally, the *carbonic acid* must also be added to the constituent ingredients in saline springs. This acid is extricated, in the usual form of air-bubbles, during the evaporation of the *rough* brine; and its disengagement causes the separation of the calcareous earth, now deprived of its solvent. The same escape of this volatile acid, and the same separation of the calcareous earth, likewise take place when the brines are *graduated*; in which case the carbonated



ated calcareous earth, together with the oxyd of iron, settles around the brush-wood, through which the brine passes, and forms the *dornenstein*. On this account, the graduated brines contain a much smaller proportion of calcareous earth; which, at the process of boiling, is fully deposited, and assists, in combination with the selenite, to form the compound with which the boiler is incrustated. (*Pfannenstein*).—What concerns the proportion of *carbonic acid*, contained in salt-springs, in a state of absorption, I did not, in particular, attempt to ascertain; as such enquiries cannot be made with any prospect of success, but with brines recently collected, and employed on the spot.

## XXVII.

## CHEMICAL EXAMINATION

OF

## SPINELL.

THE *spinell* seems to belong to those species of gems, which the antients understood by the name *Hyacinth*; as they do not ascribe to it the yellowish red colour, possessed by our modern hyacinth, but a light violet-red, and also a rose-red. Pliny\*, for example, says:—“*Multum ab amethysto distat hyacinthus, tamen e vicino descendens. Differentia hæc, quod ille emicans in amethysto fulgor violaceus, dilutus est in Hyacintho.*” Epiphanius enumerates five species of hyacinth, the third of which he calls NATIBOS†, stated by Salmassius to have been of a colour, *qui inter roseum est, et dilutiorem*. That the stone, now called hyacinth, has been mistaken for the hyacinth of the antients, was probably occasioned by the following passage of Pliny‡:—“*Hyacinthos Æthiopia mittit et chrysolythos aureo colore translucetes.*” But if in consequence of a sounder criticism the context be read thus:—*Marcescens celerius nominis sui flore hyacinthus. Æthiopia mittit et chrysolithos*, &c. it is obvious, that the *aureus* colour is referred to the chrysolite, which, as is well known, is the *topaz* of our days, and that it has nothing to do with the *hyacinthus* of the preceding sentence. In this way, also, another apparent contradiction in Pliny is removed.

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\* Lib. xxxvii. cap. 9.

† From the Arabic word, *Natif*, a red crayon colour. See Joan. de Lact de Gemmis et Lapidibus. Lugd. Batav. 1647.

‡ Loc. cit.



The reader likewise knows that the spinell has been hitherto ranked along with the *ruby* as its second species, so that the first species of that genus has included the true genuine ruby. But since *Rome de l'Isle*\* has directed the attention to the different form of crystallization of those two stones: observing that the crystals of the genuine ruby of *Pegu* are oblong, double, hexahedral pyramids, modern mineralogists have, upon this ground, ranked the *ruby* under the sapphire, as a red variety of it, and introduced the *spinell* as a distinct genus; which separation is also suggested by the difference of its hardness and specific gravity.

Besides these distinctions, the nature of the fracture also might serve to discriminate the genus. For the texture of the spinell is lamellar, in triple transverse laminas; the sapphire, on the contrary, exhibits in every direction only a flat conchoidal fracture†.

Yet the surest way to decide on this point would be by chemical analysis; which, however, with respect to the ruby crystallized in hexahedral pyramids, or the red sapphire, can be at present but little hoped for, as it is so seldom met with in its rough state.

The original figure of spinell is the octahedron, or double four-sided pyramid. This crystalline figure is frequently found perfectly regular, but as often subject to many variations, which have been detailed and described with great diligence, and uncommon accuracy, by Abbé *Estner*‡.

No less variable is the colour of the spinell; as it passes through almost all the shades of the red. This variation

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\* *Cristallographie*, tom. i. page 213.

† *Estner*, *Mineralogie*, II. B. I. Abth. S. 96, 97.

‡ *Ibidem*, page 73. seq.

of colour has induced jewellers, or dealers in gems, to subdivide the genus of ruby, besides the *genuine ruby*, into *almandin*, *spinell*, *ballafs*, and *rubicell*, as they usually do.

The red colour of this gem is not only very fixed, or permanent in the fire, but its pale variations are even still more heightened by means of a careful ignition. This property the inhabitants of Ceylon know how to employ to advantage, according to the testimony of *Julius Scaliger* ;\* and, perhaps, on this dexterity of art depends the amazingly high and magnificent colour which we admire in fine, polished rubies, but do not perceive in the rough, uncut stones.

To the more uncommon variations of colour belong: 1. the spinell, quite *colourless*, and as limpid as water, of which Mr. *Macie*, in London, possesses a perfect octahedron in his collection of crystals; 2. the *sapphire-blue* spinell, in the collection of *Francis Greville*, Esq.; and 3. the *green* spinell, the property of *J. Hawkins*, Esq. likewise in London, &c. &c. This affords a new example, that, in determining the genera and species of gems, colour is to be considered as only a subordinate or *secondary* character.

The specific gravity of spinell I have found to be, in selected crystals, from 3,570 to 3,590.

Although several years ago I attempted and published a chemical analysis of the spinell†, I have found some circumstances then not completely ascertained, which require ano-

\* *Exercitationes*, &c. No. cxviii.

† *Beob. u. Entdeck. a. d. Naturkunde*, vol. iii. Berlin, 1789. page 336.



ther analytical process. The result of this has taught me, that on the first analysis of the spinell, I had thoroughly overlooked one of its constituent parts, which I did not suspect in it, and which is *magnesian-earth*. Among the various experiments, instituted for accurately determining the proportion of this newly discovered ingredient, I select that in particular, which led the nearest to fulfilling this object.

a) One hundred grains of rough spinell from Ceylon, in picked crystals, previously pounded to a coarse powder in the steel-mortar, were triturated with water to an impalpable powder in the grinding-dish made of flint. After the powder of the stone, which was again dried, had been gently ignited, it shewed an increase of weight of nine grains, originating from the particles abraded from the substance of the grinding-vessel.

b) I then strongly digested that powder with two ounces of muriatic acid. When the acid had been evaporated nearly to dryness, I diluted the mass with water, threw it upon the filter, and saturated the yellow muriatic solution with caustic ammoniac. A brown flocculent *oxyd of iron* fell down, which, collected and ignited, weighed  $1\frac{1}{4}$  grain.

c) The liquor separated from that precipitate was concentrated by evaporation, perfectly neutralized with muriatic acid, and, lastly, combined with dissolved oxalat of pot-ash (salt of wood-sorrel). In consequence of this, oxalat of lime precipitated; which, when carefully collected, and heated to redness in the cavity of a compact piece of charcoal, with the assistance of the blow-pipe, afforded three fourths of a grain of lime, or pure *calcareous earth*. This last, dissolved in nitric acid, and treated with the sulphuric, produced selenite, or sulphated lime.

d) Upon



d) Upon the powder of the stone, extracted by the muriatic acid, was poured ten times its quantity of alkaline lye, one half of which consisted of caustic alkali; which mixture being first evaporated to dryness, in a silver-vessel, upon a sand-heat, was afterwards ignited during the space of an hour. When the mass had been again softened with hot water, it left on the filtering paper 54 grains of an isabella-yellow residue when dried in the air.

e) These 54 grains were a second time mixed, and inspissated with a tenfold quantity of the same caustic lixivium, and afterwards ignited. Upon which, the mass, softened again with water, deposited a residue of a fine pulverulent form, weighing 43 grains, when dried in the air.

f) I then neutralized the yellow alkaline solution (d) and (e) by means of sulphuric acid, and by affusing more acid, made a clear solution of the precipitate, which then formed. Carbonat of pot-ash, added in a boiling state, threw down from it a precipitate of a very great bulk, which, after edulcoration, was again dissolved in sulphuric acid. This solution exhibited a slimy toughness; but it became perfectly fluid, when exposed to a raised temperature, and deposited a subtle white powder, which, after washing and desiccation in the air, weighed 95 grains. The sulphuric acid fluid, when separated from it, was set aside for a time.

g) The above-mentioned 95 grains were then gently ignited with thrice their quantity of caustic pot-ash. When again liquefied with water, and filtered, there remained only a slight residue, which, after washing, dissolved in sulphuric acid, with the exception of a few remaining particles.

b) The



b) The portion taken up by the caustic pot-ash in the alkaline solution (g), was precipitated by means of sulphuric acid. But it dissolved again in the acid, when added to excess, and was afterwards precipitated by boiling with mild, or carbonated alkali. This precipitate, previously washed, was once more dissolved in sulphuric acid.

i) The whole of the sulphuric solutions, obtained at (f, g, b), was evaporated to a smaller compass. The gelatinous consistence, into which it congealed, shewed that a separation of siliceous earth had taken place. It was therefore largely diluted with water, digested, and the filix collected upon the filter.

k) This done, the sulphuric solution was put in a state to crystallize, by dropping into it a solution of acetite of pot-ash\*, and evaporating it slowly. It yielded at first regular and pure crystals of alum. But as the solution assumed a green colour towards the end, I combined it with Prussian alkali. A trifling precipitation ensued, of which the *oxyd of iron* could not be estimated more than at one fourth of a grain. The solution, being now freed of its ferruginous ingredient, was next decomposed, in a boiling heat, by carbonated pot-ash; and the precipitate, when dissolved anew in sulphuric acid, was brought to a final crystallization; after which the sulphat of alumine then obtained was added to the foregoing.

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\* Note. In order to add the vegetable alkali in the just proportion requisite to promote the crystallization of the sulphated alumine, I find it at present most convenient to employ that alkali in a state of saturation with acetic acid. By this manner I avoid the danger of decomposing a part of the alum just forming, by the quantity of alkali, that may easily happen to be added in excess.

l) I now proceeded to the analysis of the 43 grains, that were left undissolved by the caustic alkaline lye (e). These readily dissolved in dilute sulphuric acid, leaving some siliceous earth behind. The solution, separated from this last, was then combined with a small portion of acetated pot-ash, and exposed to spontaneous crystallization by exhalation in the open air. At first there yet appeared some solitary crystals of alum; but afterwards it entirely shot into *sulphat of magnesia* (Epsom salt).

m) To separate the sulphated magnesia, thus obtained, from the admixed sulphat of alumine, it was strongly ignited in a porcelain-vessel during half an hour, and the saline mass afterwards softened in water, and filtered. The aluminous, or argillaceous earth, separated by this management, was afterwards dissolved in sulphuric acid, and in the proper manner crystallized into concrete alum.

n) The pure solution of the sulphated magnesia was precipitated in a boiling heat by means of vegetable alkali. The *magnesian earth*, thus obtained in a carbonated state, weighed  $20\frac{1}{2}$  grains, when washed and dried; but after strong ignition it weighed only  $8\frac{1}{4}$  grains.

o) All the washings (of which that at (f), on precipitating the sulphuric solution by carbonat of pot-ash, retained the yellow colour of the first solution) were, together, evaporated to a dry saline mass. When they had been re-dissolved in water, there still separated a little earth, which, along with the precipitate remaining at (g), was ignited with caustic pot-ash, and then by sulphuric acid resolved into *aluminous* and *siliceous* earths.

p) The whole quantity of alum obtained at (k, l, m, and o) amounted to 665 grains. It was now dissolved in water,  
and



and in a heat of ebullition decomposed by carbonated alkali prepared from tartar. The *aluminous earth*, thus obtained, when edulcorated with water, and dried in a moderate warmth, weighed 221 grains. But, after being purified by digestion with distilled vinegar, and subsequent saturation with ammoniac, and being again edulcorated, and at last subjected for half an hour to an intense red heat, it weighed no more than  $74\frac{1}{2}$  grains.

q) I then ignited, for half an hour, the whole of the *siliceous earth* collected from (i, l, o). Its weight was  $24\frac{1}{2}$  grains. Hence, subtracting the nine grains which had been abraded from the flint-mortar (a), there remain  $15\frac{1}{2}$  grains belonging to the spinell.

From this analysis it follows, that the constituent parts of the *spinell* in the hundred are:

|                     |           |    |           |        |
|---------------------|-----------|----|-----------|--------|
| <i>Alumine</i>      | . . . . . | p) | . . . . . | 74,50  |
| <i>Silex</i>        | . . . . . | q) | . . . . . | 15,50  |
| <i>Magnesia</i>     | . . . . . | n) | . . . . . | 8,25   |
| <i>Oxyd of iron</i> | . . . . . | b) | 1,25 }    | 1,50   |
|                     |           | k) | 0,25 }    |        |
| <i>Lime</i>         | . . . . . | c) | . . . . . | 0,75   |
|                     |           |    |           | <hr/>  |
|                     |           |    |           | 100,50 |

The reason why, in this instance, there appears in the sum of the weights an excess of half a grain, rather than a loss, unavoidable in the usual course of such processes, is probably, that the ignition was not powerful enough to effect in those ingredients that high degree of dryness, which that stone possesses in its natural, undecomposed state.

With regard to another analytical process made with spinell, and of which it would be superfluous to give a detailed description, as it only served to pave the way to the foregoing, I shall here merely relate the following phenomenon.—When the cohesion of the parts which constitute that stone had been loosened by alternate treatment with caustic pot-ash and muriatic acid, I introduced the earth, precipitated by ammoniac from the muriatic solution, into caustic alkaline lye. It dissolved therein for the most part, but not wholly. The undissolved remainder was upon this dissolved in muriatic acid; and when the siliceous earth, which then appeared, had been removed, the fluid was again evaporated to a smaller volume.

After some days standing, there appeared in it a quantity of small crystalline groups, consisting of clear, and seemingly quadrilateral, somewhat flattened, little columns; the greater number of which were joined by two and two, in the form of an X, but the others in groups of three, and more, in a stellated manner.

These crystals readily dissolved in water. The precipitate, thrown down by caustic ammoniac, was of a light-brown, on account of some portion of iron, which still adhered. It was then dissolved in sulphuric acid, and this new combination was again set to crystallize in the slowest manner. At first there appeared crystals of alum; but the remainder of the solution gradually shot into four-sided columnar crystals of sulphated magnesia.

It is this crystallization of *magnesia*, mixed with *alumine* in muriatic acid, which I think worth remarking.



## XXVIII.

## CHEMICAL EXAMINATION

OF THE

*EMERALD from Peru.*

THE *emerald* is one of the best known gems, and it has been reckoned even in remote antiquity among the most esteemed precious stones, on account of its rich green colour, so grateful to the eye. *Pliny* enumerates *twelve* species of it, and considers the *Scythian*, *Bactrian*, and *Egyptian*, as the most eminent. However, it can hardly be doubted, but that, in those days, various essentially different species of stones of a green colour were comprised under that name; as is frequently done in our days. The acquaintance of Mineralogists with the genuine emeralds, which were furnished by the parts of the globe the longest known, seems at present to be almost entirely obliterated by our familiarity with those which are found, though sparingly, in the provinces of *South-America*, and principally in *Peru*.

a) For the following analysis I made use of the crude, crystallized emerald, of a high grass-green colour, from *Peru*\*. I pounded it in a steel-mortar to a coarse powder, and triturated *one hundred* grains of that powder very finely

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\* For the specimen of emerald sacrificed to this analytical process, I am indebted to the liberal kindness of Prince *Dimitri Galitzin*, whose zeal for the study of Mineralogy is most honourably known.

with water, in the flint grinding-dish. After gentle ignition, I found its weight increased by about  $1\frac{1}{2}$  grain.

b) The powder of the stone was covered, and several times digested in a strong heat, with muriatic acid; which immediately acquired a yellow colour. After having again filtered off the acid, I saturated it to excess with caustic ammoniac; and by this management there separated light, brown flocculi, which, collected and ignited, weighed half a grain, and were *oxyd of iron*. The fluid was next evaporated to a part, and treated with carbonated ammoniac. But it continued clear, and thus shewed, that it contained no calcareous earth.

c) *Fourteen* drachms of caustic alkaline lye, made of seven drachms of the salt dissolved in as many of water, were then affused upon the powder of the stone extracted by the muriatic acid (b); and after the mass had been previously evaporated to dryness in a silver-crucible, I subjected it to a red-heat for half an hour. However, it would not fuse, but appeared, after ignition, in an intumesced, friable state, and of a white colour.

d) On being softened with water, and treated with abundance of muriatic acid, it afforded a very limpid solution, from which the earthy ingredient was precipitated by carbonated pot-ash, with the assistance of heat. The precipitate had a granular form; and when finely ground, the greatest part seemed to dissolve in muriatic acid, which was poured upon it. But as soon as the mixture had been exposed to a digesting heat, it coagulated to a transparent thick jelly. When diluted, and digested with more water, it deposited siliceous earth to the amount of 67 grains, after washing and ignition. This earth was then mixed with four parts of carbonated pot-ash, and ignited to an incipient fusion,



fusion, in a crucible made of silver. Upon the mass, redissolved in water, which afforded a somewhat turbid solution, I poured muriatic acid to an excess of saturation, and digested them together. The *siliceous earth*, which I thus recovered, was now perfectly pure, and weighed  $63\frac{1}{2}$  grains, after having sustained a red heat.

e) The muriatic solution, separated from this *silex*, together with the preceding (b), was saturated with an overproportion of caustic ammoniac. The paste-like precipitate, thence arising, was immediately removed, and the filtered liquor combined with carbonat of ammoniac; which, however, would throw down nothing more. Sulphuric acid quickly dissolved this precipitate. By the addition of a little acetate of pot-ash, the whole of the solution yielded crystallized alum, with the exception of some *silex*, which still separated, and weighed  $4\frac{1}{2}$  grains, after ignition.

f) From the above sulphat of alumine (e) being redissolved in water, I precipitated the argil by carbonated pot-ash. When the earth had been again deficcated, I poured upon it distilled vinegar; put the whole in a warm place; saturated the acetic acid with caustic ammoniac; and, lastly, filtered the mixture. What remained of the fluid suffered no alteration, either by carbonat of ammoniac, or by carbonat of soda. The *aluminous earth*, now obtained in a state of purity, was first dried, then ignited, and found to weigh  $31\frac{1}{4}$  grains.

Therefore, the constituent parts of *one hundred* grains of *Peruvian emerald*, here decomposed, yielded:

|                          |    |                        |         |
|--------------------------|----|------------------------|---------|
| <i>Silex</i>             | d) | $63\frac{1}{2}$ grains |         |
|                          | c) | $4\frac{1}{4}$         |         |
|                          |    | <hr/>                  |         |
|                          |    | $67\frac{3}{4}$        |         |
| Subtract                 | a) | $1\frac{1}{2}$         |         |
|                          |    | <hr/>                  |         |
|                          |    | $66\frac{1}{4}$        | $66,25$ |
| <i>Alumine, or argil</i> | f) |                        | $31,25$ |
| <i>Oxyd of iron</i>      | b) |                        | $0,50$  |
|                          |    | <hr/>                  | $98$    |



## XXIX.

## CHEMICAL EXAMINATION

OF THE

*BOHEMIAN GARNET.*

THE denomination *garnet* served to the elder Mineralogists as a generic, or *collective-name*, in which they included almost all roundish crystalline forms, encompassed by defined lateral facets, or all the species of stones, of, as they were called, a polyhedral crystallization. At present, however, the *generic name*, *garnet*, has been confined within narrower limits; for the *white garnet*, as well as the *black*, have been justly removed from it, and arranged as distinct genera: the first under the name *Leucite*; the second under that of *Melanite*.

It may also be foreseen, that several other fossils now classed as species, or as varieties of the garnet, besides those last mentioned, will in time receive another place in the systematic arrangement of minerals: in consequence of more accurate observations concerning the deviation, not only with regard to their external appearance, but likewise with regard to their chemical constituent parts, by which they are distinguished from the true and strictly determined principal genera, to which last the Bohemian garnet principally belongs.

The *Bohemian garnet*, (whose occurrence, method of procuring it from the mines, and external characters, are too well known to require any farther illustration in this place),

place), when weighed in water, lost 269 parts of 1000 of its absolute weight; its specific gravity therefore is = 3,718.

It fuses by itself alone in a proportionate intensity of heat\*. The iron which it contains is reduced to the reguline state, when exposed to the action of fire in the charcoal-crucible. From 100 grains of Bohemian garnet I obtained a button of iron, of  $10\frac{1}{8}$  grains weight.

In order to find out its constituent parts, I subjected it to the following experiments.

a) I ground *two hundred* grains of Bohemian garnet, previously pounded in the steel-mortar, with water, to a subtle powder, in the flint triturating dish. When dried, and gently ignited, the powder of the stone was found increased in weight by seven grains. I inspissated it with a lixivium, made of 600 grains of caustic pot-ash, in a silver-crucible, and ignited it afterwards for half an hour. The ignited mass was then softened with water, lixiviated, and filtered. The filtered lixivium was of a light grass-green, but soon lost that colour, and became light-brown. By exposure to a warm temperature, it deposited, after 24 hours, an *oxyd of manganese*, which, collected in a porcelain-cup, amounted to about half a grain. On fusing it upon charcoal, with a neutral phosphat, and covering it with nitrat of pot-ash, the salt exhibited, after detonation, a dark violet-red colour, mingled with green spots.

b) The alkaline lye was then super-saturated with muriatic acid, and evaporated nearly to dryness. After re-dissolving the saline mass in water, *siliceous earth* was deposited, which weighed 11 grains, after edulcoration and ignition. When

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\* See Essay I. No. 39.



this had been separated, some *aluminous earth* was thrown down by carbonated soda from the muriated solution. As the remaining liquor still appeared of a yellow tinge, it was again evaporated to a dry salt. But this likewise had a citron-yellow colour, and again afforded a yellow solution with water; from which, however, nothing could be farther separated, by any means whatever.

c) The lixiviated powder of the garnet had the colour of a light-brown iron ochre. To this I added the small portion of alumine (*b*), and treated it with muriatic acid, with which it immediately formed a golden-yellow solution. When this last had been evaporated, in a sand-heat, to a gelatinous consistence; it was again largely diluted with water, once more digested and filtered. The *siliceous earth*, being well lixiviated, and heated to redness, weighed 76 grains.

d) Caustic ammoniac threw down from the muriatic solution a copious brown precipitate; which, after being collected on the filtering paper, was washed, and dried in a moderate warmth.

e) The colourless fluid, remaining after the precipitation with caustic ammoniac (*d*), was evaporated in part, and combined with carbonated soda. By this management, carbonate of lime fell down, which, after drying, weighed  $12\frac{1}{2}$  grains, equal to seven grains of *ignited calcareous earth*, or burnt lime.

f) I then divided the brown precipitate, obtained by means of ammoniac (*d*), into two equal parts.

One half of it I exposed to strong ignition in a covered crucible, and found, after this, its weight to amount to 55 grains.

g) The

g) The other half I dissolved again in muriatic acid, diluted the solution with a sufficient quantity of water, and precipitated its portion of iron by Prussian alkali. The separation of the dark-blue precipitate being accomplished, I precipitated the solution, now freed from iron, by means of carbonated soda, and in a boiling heat. The quantity of the white, loose earth thus obtained amounted, after washing, drying, and ignition, to  $38\frac{1}{2}$  grains.

From this it was manifest, that the proportion of *oxyded iron*, separated by prussiated pot-ash, amounted to  $16\frac{1}{2}$  grains.

b) The above  $38\frac{1}{2}$  grains of ignited earth (g), were then dissolved in sulphuric acid, and made to crystallize, after the addition of a proper quantity of acetated pot-ash. The first shootings yielded regular crystals of alum. But the last shewed, by the oblong, four-sided columnar figure of its crystals, that it was sulphat of magnesia.

i) But as the sulphat of magnesia could not be separated from the alumine with sufficient accuracy, I subjected the whole of the saline mass to strong ignition for an hour; after which I liquefied the ignited mass with water, and combined the mixture, at a raised temperature, with powder of calcined oyster-shells, added in small portions, until the solution no longer reddened paper tinged with litmus. The filtered solution tasted now like pure sulphat of magnesia; and, when set to crystallize, I obtained from it 69 grains of this neutral salt. However, on being re-dissolved in water, it still deposited two grains of sulphated lime: hence its true quantity amounted to 67 grains.

k) To recover from it the earth in a separate state, I precipitated the solution, in a boiling heat, by carbonat of soda.



foda. The *magnesian earth*, washed and dried, weighed  $23\frac{1}{4}$  grains; but when heated to incandescence in a covered crucible, and kept in that state during half an hour, it weighed but 10 grains.

By subtracting these 10 grains of magnesia from the above  $38\frac{1}{2}$  grains (*g*), there remain  $28\frac{1}{2}$  grains for the aluminous earth.

One hundred grains of *Bohemian garnet* consist, therefore, of:

|              |   |   |   |   |    |                |
|--------------|---|---|---|---|----|----------------|
| <i>Silex</i> | . | . | . | . | b) | $5\frac{1}{2}$ |
| —            | . | . | . | . | c) | 38             |

$43\frac{1}{2}$

|               |   |    |                |
|---------------|---|----|----------------|
| and deducting | . | a) | $3\frac{1}{2}$ |
|---------------|---|----|----------------|

40 . . . . 40,

|                |   |   |   |    |   |   |   |   |   |       |
|----------------|---|---|---|----|---|---|---|---|---|-------|
| <i>Alumine</i> | . | . | . | k) | . | . | . | . | . | 28,50 |
|----------------|---|---|---|----|---|---|---|---|---|-------|

|                     |   |   |    |   |   |   |   |   |   |       |
|---------------------|---|---|----|---|---|---|---|---|---|-------|
| <i>Oxyd of iron</i> | . | . | g) | . | . | . | . | . | . | 16,50 |
|---------------------|---|---|----|---|---|---|---|---|---|-------|

|                 |   |   |    |   |   |   |   |   |   |     |
|-----------------|---|---|----|---|---|---|---|---|---|-----|
| <i>Magnesia</i> | . | . | k) | . | . | . | . | . | . | 10, |
|-----------------|---|---|----|---|---|---|---|---|---|-----|

|             |   |   |    |   |   |   |   |   |   |      |
|-------------|---|---|----|---|---|---|---|---|---|------|
| <i>Lime</i> | . | . | e) | . | . | : | . | . | . | 3,50 |
|-------------|---|---|----|---|---|---|---|---|---|------|

|                          |    |   |   |   |   |   |   |   |   |      |
|--------------------------|----|---|---|---|---|---|---|---|---|------|
| <i>Oxyd of manganese</i> | a) | . | . | . | . | . | . | . | . | 0,25 |
|--------------------------|----|---|---|---|---|---|---|---|---|------|

98,75

## XXX.

## CHEMICAL EXAMINATION

OF THE

## ORIENTAL GARNET.

THE *Oriental*, or *Sirianic Garnet* \*, is distinguished from the *Bohemian*, both by its violet-red colour, and by its specific gravity; which is = 4,085. This higher weight of it depends on the greater proportion of iron which it contains, and which is so considerable, that, by mere fusion in the charcoal-crucible, I obtained from 100 grains of the oriental garnet a fine button of iron, of 23 grains. It likewise, when fused alone, in a crucible made of clay, runs into an enamel glass of a blacker colour than that of the Bohemian garnet †.

a) Two hundred grains of oriental garnet, previously bruised into small pieces, in the steel mortar, acquired eight grains additional weight from the substance of the flint-grinding dish, in which they were finely levigated with water. The powdered garnet was put in a caustic lye, in which the alkaline ingredient constituted thrice the weight of the powder; and, with this, it was inspissated to a dry mass, in a crucible made of silver. It was next subjected to red-heat during half an hour; and when the ignited mass

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\* Rather *Sirianic*, than *Sirian garnet*: from *Sirian*, a town in *Pegu*, now destroyed.

† See Essay I. No. 40.



had again been softened with boiling water, the powder of the stone, separated from the decanted liquor, was lixiviated and dried.

b) The alkaline lixivium was of a bright grass-green. But it was soon deprived of that colour by exposure to a warm temperature, at the same time that it deposited an oxyd of manganese, impregnated with iron, in a brown flocculent form, and weighing about  $\frac{1}{2}$  grain when ignited.

c) The alkaline lye was now devoid of all colour. It was saturated with muriatic acid, and evaporated in part. A light flocculent earth then separated, but part of it dissolved again upon super-saturation with muriatic acid. The insoluble residue consisted of *siliceous earth* of  $9\frac{1}{2}$  grains after ignition. That part of the earth, which had been re-dissolved by the excess of acid, was then separated afresh by carbonate of pot-ash. After ignition, this earth weighed  $4\frac{1}{2}$  grains; and, upon being tried by sulphuric acid, it proved to be pure alumine, or *aluminous earth*.

d) Theedulcorated powder of the stone (a), which had a cinnamon colour, and a very incoherent form, was moistened with water, and treated with muriatic acid, in which it rapidly dissolved, without leaving any residue. The liquor was limpid, and of a golden-yellow. But, on being subjected to evaporation, on a sand-bath, it coagulated into a semi-translucid, gelatinous substance; which had a deep golden-yellow colour, and was again digested for a while along with water that was poured upon it, and with repeated stirring. When, after this, it had been brought upon the filter, it left *siliceous earth* in a swelled state; which, being thoroughlyedulcorated by a frequent affusion of hot water, and deficcated, weighed 104 grains, but only 70 grains when heated to redness.

e) To

e) To the muriatic solution, diluted with the washings of the filix (d), I added caustic ammoniac in excess. It gave a copious brown-red, much intumesced precipitate, the quantity of which, after washing and drying, amounted to 190 grains.

f) The colourless fluid remaining from this last process was first combined with as much muriatic acid as was requisite to saturate the predominant portion of ammoniac, and then with carbonated soda. But as this produced no turbidness, I evaporated the whole of the liquor to a dry saline mass, which being re-dissolved in a little water, I tried it once more with carbonat of soda. The mixture still continuing clear, shewed, that it contained no other constituent part.

g) Those 190 grains of the brown-red precipitate, obtained at (c), were divided into two parts.

One half was ignited, and then found to weigh 61 grains. I poured upon it sulphuric acid, evaporated it to dryness; and after having strongly ignited the saline mass for two hours, in a melting pot, I extracted it with water, and combined the filtered, clear fluid with carbonated soda, in a heat of ebullition. There separated, however, some scarcely perceptible flocculi of aluminous earth only, without any trace either of lime, or of magnesia.

h) The other half of the precipitate was dissolved in muriatic acid; and, after sufficient dilution with water, combined with Prussian alkali, added successively, till all the ferruginous parts were separated. The blue precipitate of iron weighed 185 grains, when washed and desiccated. After being strongly ignited in a covered crucible, there remained 72 grains of iron attractible by the magnet. One  
part



part of it was assayed for manganese by fusion with a phosphated alkali; but it gave no indication of this metal.

i) The solution being now freed from the iron (*b*), it was decomposed in a boiling heat, by carbonated soda, and the precipitated earth lixiviated, and heated to redness. It weighed 25 grains; whereby, subtracting it from the 61 grains, obtained from the first half of the precipitate (*e, g*), the portion of iron, contained in 100 grains of this garnet, is found to be 36 grains.

k) When the above 25 grains of ignited earth (*i*) had been dissolved in sulphuric acid, and, after the addition of acetated pot-ash in due proportion, was set to crystallize, they afforded to the end crystals of pure *sulphat of alumine*.

It results from this decomposition, that the constituent parts of the *oriental garnet* are in the hundred:

|                   |   |   |   |   |    |    |   |   |   |                 |
|-------------------|---|---|---|---|----|----|---|---|---|-----------------|
| Oxyd of iron      | : | . | . | . | i) | .  | . | . | . | 36              |
| Silex             | . | . | . | . | .  | c) | . | . | . | $4\frac{3}{4}$  |
| —                 | . | . | . | . | .  | d) | . | . | . | 35              |
|                   |   |   |   |   |    |    |   |   |   | <hr/>           |
|                   |   |   |   |   |    |    |   |   |   | $39\frac{3}{4}$ |
| Subtract          | . | . | . | . | a) | .  | . | . | . | 4               |
|                   |   |   |   |   |    |    |   |   |   | <hr/>           |
|                   |   |   |   |   |    |    |   |   |   | $35\frac{3}{4}$ |
| Alumine           | . | . | . | . | c) | .  | . | . | . | 25              |
| —                 | . | . | . | . | k) | .  | . | . | . | 25              |
|                   |   |   |   |   |    |    |   |   |   | <hr/>           |
|                   |   |   |   |   |    |    |   |   |   | $27\frac{1}{4}$ |
| Oxyd of manganese | . | . | . | . | b) | .  | . | . | . | 0,25            |
|                   |   |   |   |   |    |    |   |   |   | <hr/>           |
|                   |   |   |   |   |    |    |   |   |   | 99,25           |
|                   |   |   |   |   |    |    |   |   |   | z               |

## XXXI.

## CHEMICAL EXAMINATION

OF

## VESUVIAN.

## FIRST SECTION.

*Vesuvian, from the Mountain Vesuvius.*

AMONG the different sorts of stones, which the Mountain Vesuvius brings up from the bowels of the earth, in their native unaltered state, that crystalline fossil may be reckoned, which the inhabitants of Naples call the *Vesuvian gem*.—Mineralogists had variously classed it with shörl, chrysolite, hyacinth, topaz, &c. and by the adjective, *vesuvian*, or *volcanic*, distinguished it as a variety of the above mentioned gems; till *Werner* established it as a distinct genus of stones, and gave it the name, *Vesuvian*; as, till then, it was found on Mount Vesuvius only.

An oryctognostic description of that fossil is already met with in various elementary treatises on mineralogy. That given by *Esfner* \* is particularly accurate and complete, for which reason I direct the reader chiefly to it.

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\* *Esfner, Versuch einer Mineralogie für Anfänger und Liebhaber.*  
II. Band. Seite 177 seq.



## A.

*Examination in the dry way.*

a) A small piece of vesuvian, if ignited upon charcoal before the blow-pipe, gradually rounds itself into a dark-brown, shining, opaque globe, transparent only in splinters.

Borax (borat of soda) dissolves it by degrees, to a clear light brown, and somewhat blistered, or air-bubbled glass-button.

It is not, however, completely dissolved by means of a neutral phosphat, for this only envelopes the particles of the fossil, in the form of an amorphous frothy scoria.

The habitude of vesuvian is more remarkable, when acted upon by a greater intensity of heat in the charcoal-crucible, which I have already communicated in the *first of these essays*, page 32, n. 103. The regular group of crystallization, there described, of the tender crust that surrounds the fused vesuvian, is a phenomenon according to my experience, the only one of its kind; and repeated experiments have convinced me that it is constantly the same.

## B.

*Examination in the humid way.*

To decompose the vesuvian in the humid way, I picked out the best crystallized pieces of that variety which had a brown colour, inclining to olive-green. These were coarsely powdered, and, by elutriation, freed from the greenish-white and delicate lamellas of chlorite and mica, which still ad-

hered. Placed upon the hydrostatic balance, in this purified state, its specific gravity was 3,420.

a) *Hundred* grains of it were reduced to an impalpable powder, by levigation with water in the flint-triturating dish. After gentle ignition, its weight was found to have encreased half a grain. Caustic alkaline lye, containing 300 grains of the salt, was then affused upon it, in a silver pot; and the mixture being first desiccated in a sand-heat, was next subjected to strong ignition, during half an hour. Shortly before ignition the mass acquired a vivid, light, grass-green colour, but which was afterwards mostly changed into a dirty olive-green.

b) The ignited mass, while yet warm, was softened with water, and thrown upon the filter. The filtered lixivium appeared of a pale greenish hue, but soon grew feebly brown-red. During gentle digestion, there subsided loose, dark-brown, flocculent particles, leaving the lye colourless. As it could be foreseen that they would not well separate from the filtering paper, I collected them in a small porcelain-vessel, and dried them after edulcoration. By this treatment I obtained a dirty-brown powder, consisting of  $\frac{1}{4}$  grain of *oxyd of manganese*. When conveyed into fused phosphoric salt, it dissolved in it clearly. The glass-globule, thus formed, became by turns colourless and amethyst-red, accordingly as I directed on it the inner or the outer point of the flame.

c) Upon the pale-brown, loose vesuvian powder, ignited with caustic alkali (a), edulcorated and dried, I poured muriatic acid; which dissolved it, with a little effervescence, and left some *siliceous earth* behind.

d) The



d) The yellowish solution, together with the washings when reduced in bulk by evaporation, formed a clear coagulum of a full golden-yellow. By diluting it again with much water, and digesting it for some time under repeated agitation, the *siliceous earth* was rendered disposed to separation; I then collected it on the filter, and having added the foregoing portion (c), I ignited them both. They weighed together 36 grains.

e) Having thus freed the muriatic solution from all its filix, I added to it caustic ammoniac in a greater quantity than its saturation required, and immediately gathered on the filter the swelled precipitate thereby produced; which, upon being perfectly lixiviated, was conveyed into a caustic alkaline lye. It soon dissolved in it upon the fire, leaving, however, a loose, brown-red, muddy substance behind.

f) Both alkaline lixivia, that of (e), and that of (b), were then mixed, and over-saturated with sulphuric acid, till the earth, first thrown down by the acid, was again dissolved. Upon this I precipitated the earth by carbonated pot-ash, edulcorated and re-dissolved it in fresh sulphuric acid, adding then a small portion of acetated pot-ash, and prepared the solution for crystallization. It yielded crystals of alum to the end, which I re-dissolved in water, and precipitated its earthy portion by pot-ash. The *aluminous earth* here obtained, when washed and ignited, weighed  $19\frac{1}{2}$  grains.

g) That fluid, which remained on the precipitation, effected by caustic ammoniac (e), was then concentrated by evaporation, and mixed with carbonated ammoniac. Sixty grains of *crude calcareous earth*, or carbonat of lime, fell down; which, in the ignited or pure state, are equal to 33 grains.

b) The brown residue, remaining from the solution of the argillaceous precipitate, in the caustic lye (c), was found to weigh 13 grains upon exsiccation. Muriatic acid was poured upon one half of it, and completely dissolved it. Prussiat of pot-ash, which was next added, produced a quantity of Prussian blue, of a pure deep colour. Carbonated ammoniac poured into the liquor, separated from this last, still precipitated some aluminous earth, weighing 1 grain after ignition. The second half of that brown residue weighed five grains after exposure to red-heat. From this it followed, that for the above-mentioned 13 grains of residue, we must reckon  $7\frac{1}{2}$  grains of ignited oxyd of iron, and  $2\frac{1}{2}$  of ignited aluminous earth. Some experiments made with that oxyded iron, to detect whether it contained manganese, evinced it to be absolutely free from this ingredient.

Hundred parts of *vesuvian* from Mount *Vesuvius*, therefore, contain:

|                                            |                             |
|--------------------------------------------|-----------------------------|
| <i>Silex</i> . . . . d) . . .              | 36 grains.                  |
| <i>Subtrahē</i> . . a) . . .               | $\frac{1}{2}$               |
|                                            | <hr/>                       |
|                                            | $35\frac{1}{2}$ . . . 35,50 |
| <i>Lime</i> . . . . . g) . . . . .         | 33                          |
| <i>Alumine</i> . . . . . f) . . . . .      | $19\frac{3}{4}$             |
| <hr/>                                      | <hr/>                       |
|                                            | b) . . . $2\frac{1}{2}$     |
|                                            | <hr/>                       |
|                                            | $22\frac{1}{4}$ . . . 22,25 |
| <i>Oxyd of iron</i> . . . . . h) . . . . . | 7,50                        |
| <i>Oxyd of manganese</i> b) . . . . .      | 0,25                        |
|                                            | <hr/>                       |
|                                            | 98,50                       |

## SECOND SECTION.

### *Vesuvian from Siberia.*

THE fossil, which I here introduce by that name, belongs to the discoveries, as yet little known, made in Siberia, a country,



country so extensive and abundant in remarkable mineral substances. It was discovered in the year 1790, by *Lakmann*, at the mouth of the river *Achtagda*, where it falls into the stream *Wilui*. The first notice of it has been given by *Pallas*\*, under the name *Crystals of Hyacinth*, together with a delineation of some of these crystals, added to their description.

Their external colour is a dark olive-green, which, in the interior surface, passes into the brown of *colophony* (the residue of distilled turpentine). Their form is a rectangular four-sided column, with truncated edges; yet the facets of the truncations are sometimes so large, that the crystals might almost be called eight-sided prisms.

In the entire crystals both ends of the column are sharpened off to a quadrilateral pyramid. The points, however, are more or less, and in part, very much truncated.

As to the size of these crystals, the breadth of the column, in the specimens which I possess, is from  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch; and the length, not measuring the pointed termination, from  $\frac{1}{2}$  to a whole inch.

The external lustre is but moderate; the internal is brighter, and partaking of the greasy gloss. The fracture is of the imperfect, small conchoidal kind, and distinctly exhibits, especially the longitudinal one, a foliated texture.

This fossil is opaque in its entire crystals; but its fragments are transparent, and even semi-pellucid.

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\* *Pallas Neue Nordische Beyträge*, vol. v. Petersburg and Leipzig, 1793, page 282.

The gangue consists of a pale, greenish-grey, dull stone, which seems to be of the serpentine kind; and in which those crystals are singly imbedded.

Of one of those crystals, whose absolute weight was 253 grains, I found the specific gravity to be 3,365; that of another, weighing 188 grains, was 3,390.

On some of those crystals there are observed small, opaque, insulated grains, formed like garnets, and of a greenish or yellowish-white colour. Some of these adhere but loosely; but others are more deeply concreted with the body of the crystals; yet, notwithstanding this, they may be easily separated, though they leave a cavity on the surface fitting their figure and size. When fused before the blow-pipe, they run into a dark-brown smooth globule.

It has already been remarked by *Pallas*\*, that this fossil highly resembles the vesuvian of Italy; and this agreement has been more determined by *Estner*†, on the ground of the external characters of both. This oryctognostic conjecture has been confirmed by the following chemical examination,

### A.

#### *Examination in the dry way.*

a) The vesuvian from Siberia, either when ignited by itself, upon charcoal with the assistance of the blow-pipe, or when fused, under the same circumstances, with *glass of borax*, or with a *neutral phosphat*, shews, in every respect, the same

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\* *Loc. cit.*

† *Versuch einer Mineralogie*, vol. II. page 184.



relations as that from Mount Vesuvius, treated of in the foregoing section.

b) One piece of it inclosed in the charcoal-crucible, and committed to the fire of the porcelain-furnace, fused to an ash-grey, dense, vitreous globe of a gross-conchoidal fracture, and pellucid in thin fragments, the external surface of which was beset with numerous grains of iron.

But I have not perceived, on this globe, any distinct trace of that crystalline crust, by which the Italic vesuvian, if fused in the same manner, is rendered so peculiarly remarkable.

### B.

#### *Examination in the humid way.*

a) One hundred grains of the above fossil, taken from a perfectly pure crystal, were finely pulverized with water in the flint-grinding dish. Their weight increased half a grain. When inspissated with a solution of 300 grains of caustic pot-ash, and afterwards ignited for half an hour, a pale-greenish mass was produced, inclining here and there to the brownish, which, lixiviated with water, left a light-grey powder upon the filtering paper.

b) The lye, recently filtered, had a pale, dirty-brownish colour, but it soon became colourless; and, at the same time, that some few brownish flocculi were deposited, which, undoubtedly, were *oxyded manganese*, but could not well be collected and examined, from their very minute quantity. When that lixivium had been neutralized with muriatic acid, aluminous earth fell down, which a slight excess of that acid has again entirely dissolved.

c) The undissolved residue of the alkaline solution (a) was digested with muriatic acid. There remained some  
*siliceous*

*siliceous earth*, which I separated. Caustic ammoniac was then added in excess to the yellow solution, which had been mixed with the preceding (*b*), and it threw down a very intumescent light-brown precipitate, the separation of which was accomplished in an instant.

*d*) That precipitate, duly washed, and while yet moist, I digested with caustic alkaline lye. It was but slowly dissolved in this menstruum, and left a residue, the great volume and slimy appearance of which indicated, that it could not consist merely of oxyded iron, but was still mixed with filix. For this reason, I digested it with dilute muriatic acid, and evaporated it to a thickish mass; which, being again diluted with water, deposited the *siliceous earth* contained in it.

*e*) Caustic ammoniac, added to this solution, now free from all filix, again produced a brown paste-like precipitate, that readily dissolved in caustic lye, leaving a brown flocculent oxyd of iron behind, weighing  $5\frac{1}{2}$  grains when ignited.

*f*) To the alkaline lixivium of (*d* and *e*) an over-proportion of muriatic acid was added. They were then mixed with the muriatic solution (*b*), and together precipitated by carbonated pot-ash, with the assistance of heat. The earth, thrown down by this treatment, was re-dissolved in sulphuric acid. There still appeared some *siliceous earth*, after the separation of which, the solution, by proper management, crystallized into pure alum. This being again dissolved in water, I precipitated its *aluminous earth*, purified it afterwards by means of acetic acid and ammoniac, and when dried, I heated it to redness. It then weighed  $16\frac{1}{4}$  grains.

*g*) What remained of the fluid, after the precipitation by caustic ammoniac (*e*), was evaporated to a part, and upon



this combined with carbonat of ammoniac. Thus it afforded 62 grains of carbonat of lime, which are equal to 34 grains of pure *calcareous earth*.

b) The several portions of *siliceous earth* of (c, d, and f), when ignited and weighed together, amounted to  $42\frac{1}{2}$  grains.

It then results from this analysis, that the constituent parts of the *vesuvian from Siberia* are precisely the same as those of the Italian. Only some variation takes place in their proportions, which, however, is no argument against placing them in the mineralogical system as *two species*, or even merely as *varieties* of one *species*. For an *hundred* parts of the *Siberian fossil* yielded:

|       |         |    |       |                         |
|-------|---------|----|-------|-------------------------|
| Silex | . . . . | b) | . . . | $42\frac{1}{2}$ grains. |
| minus | . . .   | a) | . . . | $\frac{1}{2}$           |

|                   |         |    |               |       |       |
|-------------------|---------|----|---------------|-------|-------|
|                   |         |    | 42            | . . . | 42    |
| Lime              | . . . . | g) | . . . .       |       | 34    |
| Alumine           | . . . . | f) | . . . .       |       | 16,25 |
| Oxyd of iron      | . . . . | e) | . . . .       |       | 5,50  |
| Oxyd of manganese |         | b) | a trace only. |       |       |

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97,75

## XXXII.

## CHEMICAL EXAMINATION

OF

## LEUCITE.

## FIRST SECTION.

THOUGH the fossil at present known by the name *Leucite* or *Leucolite*, according to others, often occurs in *Italy*, (where it constitutes one of the ingredients not only in the lavas, the crude as well as those that have been converted by volcanic fires into *tufas* and slag-sand, or *volcanic ashes*, but also of other mingled masses of rocks) yet there are but very scarce and uncertain indications of its existence in other regions\*. The *leucite* is remarkable by its very determinate specific figure, which consists of low, double octahedral pyramids, flatly sharpened off to four terminating surfaces; so that it forms a roundish crystal, inclosed in 24 trapeziums.

Still less does that leucite seem to be known, which occurs in the rocks of *Vesuvius*, either in masses or in an indefinite form, variously mingled with black mica, black acicular shörl, hornblende, crystals of *vesuvian*, &c. and which hitherto has been mostly considered as glassy felspar, or granular quartz.

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\* Of the fossils foreign to *Italy*, and taken for leucite, that in particular will most probably be confirmed as such on chemical examination, which Dr. *Reuss*, so deserving in the mineralogical history of his country, has found in *Bohemia*, and described. See his *Mineralogische Geographie von Böhmen*. Dresden, 1797, vol. II. page 311—404.



### XXXII. Chemical Examination of Leucite 349

The former denomination of this fossil, *white garnet*, *Vesuvian garnet*, *garnet-shaped shörl*, is no longer to be retained, since the improvements made in *Oryctology*. On the other hand, *Werner* has assigned to it a peculiar place in the mineralogical system, as a distinct species.

For the following analyses I have selected only such crystals of leucite ejected by Vesuvius, as, by their external appearance and internal lustre, together with the yet unchanged state of their stony matrix, (which is a black-grey corneous mass of basalt), have convinced me, that they had suffered no alteration either by volcanic fire, or by any subsequent decay. Most of them were of the size of a nutmeg and upwards. Before they were employed, they were freed as much as possible from the stony matrix adhering to their outside, and likewise from the particles of hornblende usually contained in their middle. In this purified state their specific gravity was 2,455.

#### A.

##### *Examination in the dry way.*

a) The leucite is completely infusible, if ignited alone upon charcoal. It then undergoes no manner of sensible alteration, and its splinters lose nothing of their lustre.

b) If a small fragment of it be put into fused borax, it is for a long time moved about in it before it dissolves, which it does by degrees. The glass-globule, arising from thence, is clear and light-brown

c) By fusion with a neutral phosphat, the solution is still flower, and a colourless rifted glass-pearl is produced.

d) One

d) One hundred grains of coarsely pounded leucite were exposed for an hour to a strong red-heat, in a small porcelain-pot. The loss of weight caused by this was only one-eighth of a grain.

e) Even the violent heat of the porcelain-furnace produced in the leucite only an inconsiderable change\*.

## B.

*Examination in the humid way.*

## ( I. )

a) Hundred grains of leucite, reduced to an impalpable powder, were several times digested in muriatic acid, which dissolved a considerable part. There remained a *siliceous* residue, of 54 grains, after ignition.

b) This siliceous earth was then ignited with twice its weight of caustic alkali, softened again with water, covered with muriatic acid, added to excess of saturation, and, after sufficient digestion with this last, collected on the filter, and heated to redness. It was found to have sustained, by this, a trifling decrease of weight.

c) On adding prussiat of pot-ash to the muriatic solution, a precipitate ensued of so small a quantity, as hardly to indicate one-eighth of a grain of *oxyded iron*. As, besides, this slight portion of iron, probably, does not originate from the leucite itself, but from some particles of hornblende not perfectly separable, I shall not consider it among the constituent parts of that mineral.

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\* See Essay I. No. 55.

d) Upon



d) Upon this I decomposed the solution by caustic ammoniac; and, after having separated the precipitate thus obtained, I tried the remaining liquor with carbonated soda, but no farther change was effected by it.

e) The precipitate produced by means of pure ammoniac (d) was first dried. It was next purified by digesting it with distilled vinegar, and afterwards neutralizing this acid by ammoniac. It weighed  $24\frac{1}{2}$  grains, whenedulcorated and ignited. Dilute sulphuric acid completely dissolved it to a limpid liquor, and when properly treated, the solution yielded only *alum*.

f) To obtain the earth, which possibly might have remained latent in the several washings, I evaporated these to dryness. After having re-dissolved the saline mass in water, I collected the portion of earth which still appeared. However, it amounted only to half a grain, and was *siliceous earth*.

Therefore I obtained:

|                |   |   |   |   |    |   |   |                 |       |
|----------------|---|---|---|---|----|---|---|-----------------|-------|
| <i>Silex</i>   | . | . | . | . | a) | . | . | 54              |       |
| —              | . | . | . | . | f) | . | . | $\frac{1}{2}$   |       |
|                |   |   |   |   |    |   |   |                 | <hr/> |
|                |   |   |   |   |    |   |   | $54\frac{1}{2}$ | .     |
|                |   |   |   |   |    |   |   | .               | 54,50 |
| <i>Alumine</i> | . | . | . | . | e) | . | . | .               | 24,50 |
|                |   |   |   |   |    |   |   |                 | <hr/> |
|                |   |   |   |   |    |   |   | 79              |       |
|                |   |   |   |   |    |   |   | Loss            | 21    |
|                |   |   |   |   |    |   |   |                 | <hr/> |
|                |   |   |   |   |    |   |   |                 | 100   |

( 2. )

This considerable loss, in the sum of the weights of the separated constituent parts of the leucite, during this analysis,

lysis, has induced me to repeat the experiment with some variation in the process.

a) One *hundred* grains of leucite were finely ground, and ignited during half an hour, with twice their weight of caustic pot-ash. To the mass, again softened with water, muriatic acid was added, to just the quantity necessary for saturation. When the mixture had been filtered, I edulcorated and dried the remaining undissolved powder of the stone.

b) The leucite, thus prepared for decomposition, was then extracted, in a boiling heat, by means of muriatic acid. There separated some *siliceous earth*, which weighed  $54\frac{1}{4}$  grains after having sustained a red-heat.

c) The muriatic solution was concentrated by evaporation, and tried by oxalat of pot-ash; but no precipitation nor turbidness ensued. After this I recovered the *aluminous earth* in its pure and separate state, by the same means as employed in the preceding experiment. Its weight, after ignition, likewise corresponded, to within a trifle, with that of the first analysis. It also shewed, upon farther trial, by re-agents, that, except an unimportant trace of oxyded iron, it was not in the least mixed with any other earth, of whatever kind.

d) In the same manner, nothing more, of an earthy nature, could be obtained from the edulcorating waters by evaporation.

## SECOND SECTION.

This agreement of the results of these two analytical researches increased my uncertainty where to look for the cause



cause of that loss of weight. At the same time it gave additional strength to the conjecture, long since entertained by me, that in the mixture of fossils, besides the constituent parts, found by analysis, there might be present other component principles, which have hitherto escaped discovery. That chemical decompositions of bodies, even when instituted with all possible care, are attended by some loss, is founded on the nature of the subject itself. However, the above loss was too great to be included in that which is absolutely unavoidable. It is, indeed, the shortest way to get over the difficulty, if the loss in the sum of the weight of the ingredients, although of some importance, is accounted for simply by the air and particles of water expelled. But such an explanation would by no means be capable of satisfying me in the present case.

I was fully convinced, that, in those processes, at least no earthy, or any other component part, soluble in water, had been lost. It was likewise evident, from the experiments related in the beginning of this essay, that neither *water* nor *carbonic acid* was to be sought for in leucite. For these reasons, I proceeded to other experiments, which tended to try that fossil, for the *phosphoric*, *fluoric*, and *boracic* acids; but of none of these I could discover any sign.

On the contrary, I was surprised in an unexpected manner, by discovering in it another constituent part, consisting of a substance, the existence of which, certainly, no one person would have conjectured within the limits of the mineral kingdom, and, least of all, in the natural mixture of a solid fossil, which, in a *mineralogical sense*, is simple or unmixed.

This constituent part of leucite, which now appears in the character of an *oryctognostic* or mineral substance, is no other than *pot-ash*, which, hitherto, has been thought *ex-*



*clusively* to belong to the *vegetable kingdom*, and has, on this account, been called **VEGETABLE ALKALI**.—This discovery, which I think of great importance, cannot fail to occasion considerable changes in the systems of natural history, till now established, and will serve to illustrate various phenomena in the mineral as well as in the vegetable kingdom.

The following experiments will shew the particulars.

( 1. )

a) Two hundred grains of finely triturated leucite were extracted, by repeated digestion with muriatic acid. The siliceous earth, collected on the filter, and lixiviated, weighed 109 grains after ignition.

b) The muriatic solution had a yellowish colour. When evaporated in a sand-heat, to the consistence of honey, I observed its surface covered with a pretty strong saline crust. After complete cooling, the mass appeared like a thick, golden-yellow, clear oil, full of crystals, partly of a cubical, partly of a tabular form. I gently poured off the yellow fluid, and rinsed the salt with small portions of alcohol. The solution, diluted with alcohol, was then evaporated afresh, and the small quantity of salt, which it afforded, again washed with ardent spirit, and added to the first. The salt thus obtained, and highly desiccated, weighed 70 grains. This I dissolved in water, adding some drops of ammoniac, which still separated some particles of aluminous earth. The solution was then again made to crystallize in a warm place, and it afforded only cubical crystals, some of which were lengthened to quadrilateral columns.

c) That portion of the muriatic solution, which would not shoot into crystals, was diluted with water, and decomposed



in a boiling heat by carbonated soda. The precipitate consisted of aluminous earth, weighing  $47\frac{3}{4}$  grains, when depurated, washed, dried, and ignited. Upon this I poured three times its weight of concentrated sulphuric acid, and evaporated the mixture to a moderate dryness. The mass re-dissolved in water, then combined with a solution of acetated pot-ash, and set to crystallize, shot entirely into alum.

d) I mixed the siliceous earth, obtained at (a), with double its weight of pot-ash, and kept it in a strong red-heat for the length of one hour. The mass, which had but moderately coalesced, was ground, diluted with water, supersaturated with muriatic acid, and digested. By saturation with mineral alkali or soda, the filtered muriatic solution still afforded  $1\frac{1}{2}$  grain of *aluminous earth*; which being subtracted from the first weight of the *siliceous earth* (a), there remained, for this last,  $107\frac{1}{2}$  grains.

From those decomposed 200 grains of leucite have, consequently, been obtained:

|                             |              |                         |        |
|-----------------------------|--------------|-------------------------|--------|
| <i>Silex</i> :              | . . . . . d) | . . . . .               | 107,50 |
| <i>Alumine</i> . . . . . c) |              | $47\frac{3}{4}$         |        |
| ———— . . . . . d)           |              | $1\frac{1}{2}$          |        |
|                             |              | ————                    |        |
|                             |              | $49\frac{1}{4}$ . . . . | 49,25  |
|                             |              |                         | ————   |
|                             |              |                         | 156,75 |

Hence there were still wanting . . . . . 43,25 grs.  
To account for which, I was to direct my attention to the 70 grains of salt mentioned at (b).

With a view of discovering its basis, I subjected it to the following trials:

1.) Its taste and the figure of its crystals were found to be precisely the same with those of muriatic pot-ash, or digestive salt, as it is termed.

2.) No change was effected either in the blue, or in the reddened litmus paper, by its solution.

3.) It made a crackling noise, when heated to redness, and remained behind as a body fixed in the fire.

4.) Its solution was not rendered turbid, either by carbonated soda, or by caustic ammoniac.

5.) Having poured *two* parts of strong sulphuric acid upon *three* of that salt, I caused the muriatic acid to evaporate, by means of heat, re-dissolved the mass in water, and obtained sulphat of pot-ash (vitriolated tartar) in its usual crystals.

6.) The portion of salt which yet remained I dissolved in a little water, and treated it with a concentrated aqueous solution of pure crystallized acid of tartar. *Cream of tartar*, or acidulous tartarite of pot-ash, was, by this management, immediately produced, which fell to the bottom in the form of sand. This was washed, dried, and burnt in a silver crucible; and when the coal which it produced was lixiviated, and the clear lixivium evaporated to a dry salt, it proved by every test that was applied to be a *carbonat of pot-ash*. By saturation with nitric acid, it shot into prismatic nitre, (nitrat of potash).

Therefore, the basis of those 70 grains of salt consisted solely of pure vegetable alkali, which had been neutralized by a proportionate part of the muriatic acid employed in the composition of the fossil. If now, as *Bergmann* asserts,



asserts, the alkaline basis of muriated pot-ash amounts to 61 parts in an hundred of the compound, the above mentioned 70 grains (*a*) contained 42,7 grains of pot-ash. And thus the 43,25 grains, before wanted to make up the 200 grains of leucite analysed, are accounted for to within a trifling deficiency.

Consequently by the results of this analysis, accomplished by muriatic acid, *hundred* parts of leucite consist of:

|                |           |        |
|----------------|-----------|--------|
| <i>Silex</i>   | . . . . . | 53,750 |
| <i>Alumine</i> | . . . . . | 24,625 |
| <i>Pot-ash</i> | . . . . . | 21,350 |
|                |           | <hr/>  |
|                |           | 99,725 |

( 2. )

*a*) Three hundred grains of leucite, reduced to a most subtle powder, were repeatedly digested, by boiling with four ounces of nitric acid. The *siliceous earth*, when separated by filtration, and ignited, weighed 162½ grains.

*b*) This nitric solution was next evaporated. At first it continued colourless; but towards the end it turned a little yellowish, and after refrigeration it appeared like clear, tenacious turpentine. When diluted with water, and evaporated to but a moderate degree, it congealed into a greasy saline mass, consisting of small prismatic crystals. It was then successively treated and washed with alcohol, until the salt remained in a purified state. To the solution of this salt in water a few drops of ammoniac were added; to free it from a slight portion of earth which still adhered,

A a 3

and

and which was thus thrown down, and afterwards collected on the filter. After this, the whole of the saline solution, which was now as limpid as water, by slow exhalation has shot into prismatic hexahedral crystals, weighing 123 grains, after thorough desiccation.

c) That portion of the above nitric solution, which remained mixed with the spirit of wine, and refused to crystallize, was diluted with water, and, in a boiling state precipitated, by the addition of carbonated soda. The earthy ingredient fell down in a slimy, swelled form.— This, when previously washed and desiccated, together with the foregoing light portion of earth (b), was treated with distilled vinegar, and kept for a while in a warm place. The acetic acid was then neutralized by caustic ammoniac; and the earth, precipitated afresh, collected on the filter, again washed, dried, and ignited; in which state it weighed  $70\frac{1}{2}$  grains. It now presented itself in the character of the most pure *aluminous earth*; for, when dissolved by sulphuric acid, combined with acetite of potash, and crystallized, it yielded nothing but sulphat of alumine.

d) Having collected theedulcorating water, I concentrated it by evaporation, and treated it, while boiling, with mild soda. But no further precipitation took place.

e) The above mentioned  $162\frac{1}{2}$  grains of flex were mixed with twice their weight of effloresced soda, and along with it ignited for two hours in a silver pot. Upon the mass, when softened with a little water, an overproportion of muriatic acid was added, and the whole, after some digestion, diluted with water, and thrown upon the filter. On saturating the muriatic fluid with soda, a yellowish white precipitate arose, which, after heating to redness,



redness, weighed two grains, and was *alumine*, coloured by iron. As these should be subtracted, there are only  $160\frac{1}{2}$  grains to be put in the account for the *siliceous earth*.

It then appears, that in this analytical process, the alkaline-saline constituent ingredient in the leucite was neutralized with the requisite quantity of nitric acid, and generated true nitre. But that the above constituent part is really and undoubtedly of the very same quality and nature with the vegetable alkali, has been evinced by the following examinations.

1.) The taste and crystalline figure of this salt perfectly agree with those of common nitre.

2.) When its solution had been combined with a solution of nitrated silver, or with that of acetated barytes, it continued bright and clear. This fact shews, that in the natural mixture of leucite, this alkaline-saline constituent part is contained, not accidentally and merely by the assistance of carbonic or sulphuric acid, by which it may be neutralized, but rather in a perfectly pure state.

3.) Upon a part of that salt I affused half its quantity of strong sulphuric acid, and carried on its evaporation until the nitric acid had been totally expelled. And when, after this, the residue had been re-dissolved in water, and crystallized, it produced sulphat of pot-ash in its usual crystalline form.

4.) The portion that remained I introduced into a small porcelain-vessel, and heated it to fusion, adding by degrees powdered charcoal in small portions, as long as any detonation took place.—The saline mass remaining consisted of *carbonated pot-ash*: and upon saturating it anew with ni-

tric acid, it formed again prismatic *nitrat of pot-ash*; in the same manner, as *vitriolated tartar* was produced from it by means of fulphuric acid, and *digestive salt* by means of the muriatic.

Concerning the alkaline basis of nitre, I shall take for a standard the proportion stated by *Bergmann*, according to which 100 parts of prismatic nitre contain 49 of vegetable alkali. With this, likewise, *Wenzel* very nearly agrees, as he reckons  $48\frac{1}{2}$  of pot-ash in 100 of nitre, and this small difference probably depends on this circumstance, that the latter weighed his nitre in the ignited state. As, therefore, upon this ground of calculation, the above mentioned 123 grains of nitre (*b*) contain 60,27 grains of vegetable alkali, the proportion of the constituent parts in 300 grains of decomposed leucite are as follow :

|                |   |   |   |   |           |   |   |   |   |   |   |                 |
|----------------|---|---|---|---|-----------|---|---|---|---|---|---|-----------------|
| <i>Silex</i>   | . | . | . | . | <i>e)</i> | . | . | . | . | . | . | 160,50          |
| <i>Alumine</i> | . | . | . | . | <i>c)</i> | . | . | . | . | . | . | $70\frac{3}{4}$ |
| —              | . | . | . | . | <i>e)</i> | . | . | . | . | . | . | 2               |
|                |   |   |   |   |           |   |   |   |   |   |   | <hr/>           |
|                |   |   |   |   |           |   |   |   |   |   |   | $72\frac{3}{4}$ |
| <i>Pot-ash</i> | : | . | . | . | .         | . | . | . | . | . | . | 72,75           |
|                |   |   |   |   |           |   |   |   |   |   |   | <hr/>           |
|                |   |   |   |   |           |   |   |   |   |   |   | 60,27           |
|                |   |   |   |   |           |   |   |   |   |   |   | <hr/>           |
|                |   |   |   |   |           |   |   |   |   |   |   | 293,52          |

Or in one hundred :

|                |   |   |   |   |   |       |
|----------------|---|---|---|---|---|-------|
| <i>Silex</i>   | . | . | . | . | . | 53,50 |
| <i>Alumine</i> | . | . | . | . | . | 24,25 |
| <i>Pot-ash</i> | . | . | . | . | . | 20, 9 |
|                |   |   |   |   |   | <hr/> |
|                |   |   |   |   |   | 97,84 |



( 3. )

I attempted also the resolution of leucite into its principles, by means of *fulphuric acid*.

a) Two hundred grains of finely pulverized leucite were evaporated nearly to dryness, in a mixture of 200 grains of concentrated sulphuric acid with double its quantity of water. From the mass, again liquefied with water, the *siliceous earth* was separated by filtering. It weighed 59 grains, and shewed by this, that it still contained some grains of undecomposed leucite.

b) The colourless solution afforded, by evaporation, a clear, tenacious mass; which, when again dissolved in water, presently shot, without any further addition, into regular sulphat of alumine, weighing 128 grains.

c) This alum I exposed to a red-heat, and boiled the residuc, previously powdered, with water; subtracting at the same time the predominant part of the acid, by saturation with powdered oyster-shells. The filtered and clear solution, being upon this evaporated, so as to crystallize, gave *sulphat of pot-ash*.

d) The remainder of the sulphuric solution (b) has congealed, on farther evaporation, into a greasy, finely radiated mass.

### THIRD SECTION.

In all the preceding experiments the leucite from *Vesuvius* alone was employed. But as leucites are found in various other parts of *Italy*, it was an interesting point for me to learn,

learn, whether, and how far, the constituent parts of these last agree with those of the foregoing.

With this view, I selected the leucite of *Albano*, near *Rome*.\* The specimens I have obtained of it consist of solitary grains, of the size of green or sweet peas, and larger. Their exterior colour is a yellowish-white, and their crystalline figure is for the most part indistinct, owing to the edges and angles being worn off by friction; whereas the Vesuvian leucite is externally dull, and of an ash-grey, and commonly occurs with uninjured angles and edges.—The leucite from *Albano*, on the contrary, is clearer, more translucent, and more free from hornblende, in its interior mass, than that from Mount Vesuvius.

I found its specific gravity to be 2,490.

a) An hundred grains of leucite from *Albano*, in a fine pulverulent state, were boiled with muriatic acid, and left behind them undissolved *siliceous earth*, which, after ignition, amounted to 54 grains.

b) The muriatic solution was next evaporated to dryness on a sand-heat, and the yellowish-white residue, covered with alcohol, was exposed to a warm temperature, in a high cylindrical glass. After it had cooled, I decanted the spirituous solution of the muriated alumine from the muriat of pot-ash, which lay at the bottom as a white crystalline

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\*I acknowledge my thanks for the communication of this, and a great part of the foregoing leucite to *Count Lepel*, and *Dr. Thompson*, of *Naples*. It was by this augmentation of my little stock of this fossil that I was enabled to carry my analytical processes to complete evidence.



powder; and when the alcohol had evaporated in a warm temperature, I dissolved again the residue in ardent spirit, and added the small portion of muriated pot-ash, which still subsided, to the preceding. The whole quantity of it obtained was 36 grains; of which, according to what has been said before (page 357), 22 grains are *vegetable alkali*, constituting its basis. By solution in water, and perfect purification by means of a few drops of ammoniac, and subsequent evaporation at a raised temperature, it separated in pure cubic crystals. These being re-dissolved, and combined with acid of tartar, produced cream of tartar; which, after ignition and lixiviation, afforded *carbonated pot-ash*.

c) The muriat of alumine, that was held in solution by the alcohol (b), was diluted with water, and decomposed by ammoniac. The *aluminous earth*, thus precipitated, amounted to about 23 grains, when washed, dried, and ignited.

These hundred grains of leucite from *Albano* were therefore resolved into:

|                |   |   |   |    |   |   |   |       |
|----------------|---|---|---|----|---|---|---|-------|
| <i>Silex</i>   | . | . | . | a) | . | . | . | 54    |
| <i>Alumine</i> | . | . | . | c) | . | . | . | 23    |
| <i>Pot-ash</i> | . | . | . | b) | . | . | . | 22    |
|                |   |   |   |    |   |   |   | <hr/> |
|                |   |   |   |    |   |   |   | 99    |

#### FOURTH SECTION.

THE inferences resulting from the above experiments might be in some degree questioned by those philosophers, who consider the basaltic matrix of leucite, as well as all basalts in general, as lavas, and hence would think themselves entitled to doubt the primitive origin of leucite, and the originality of its alkaline constituent

stituent part now discovered. Therefore, in order at once to obviate every possible objection, I resolved to investigate whether a leucite, the mixture of which must be acknowledged as not volcanized, even by the most obstinate Volcanists, would contain pot-ash in its natural mixture as a constituent part, though hitherto this alkali has been considered as belonging only to the vegetable kingdom. For this purpose, I selected that *irregularly shaped*, finely-grained, foliated *leucite*, mentioned at the beginning of this Essay, which either accompanies the stony masses, compounded of mica, shörl, vesuvian, calcareous spar, &c. that are ejected by Vesuvius in their original rough state; or which is concreted with them. Of these specimens, I separated for this inquiry a sufficient quantity of *leucite* in a lump or *mass*, and performed its analysis according to the method before described.

By the process I obtained, besides *flux* and *alumine*, a cubically crystallized muriated neutral salt, whose alkaline basis shewed itself to be vegetable alkali, from the circumstance of its producing cream of tartar, by combination with tartareous acid.

This enquiry into the constituent parts of that variety of leucite was satisfactory; though the determination of their *proportions* could not be accomplished with due accuracy, on account of the black needles of shörl, small wax-yellow grains of vesuvian, and the like, with which it was too abundantly mixed.

#### FIFTH SECTION.

##### ( 1. )

As the preceding analyses were all performed with those species of leucite, which remained in their unaltered original



ginal state, it remained to complete the subject by the examination of a leucite, which had sustained the action of a volcanic fire.

The specimen of leucite subjected to this experiment was picked up at *Pompeji*, and belongs to the most common varieties. It consists of detached grains, for the most part of the size of a pepper-corn. Its interior surface, like the exterior, is ash-grey, of an earthy appearance, and wholly opaque; and it may be easily comminuted to a sandy powder.

Hundred grains of it, decomposed by muriatic acid, exactly in the same manner as the leucite from *Albano* in the third section, and the muriat of pot-ash thereby obtained, calculated for its basis of vegetable alkali, have afforded:

|                |   |   |   |   |   |       |
|----------------|---|---|---|---|---|-------|
| <i>Silex</i>   | . | . | . | . | . | 54,50 |
| <i>Alumine</i> | . | . | . | . | . | 23,50 |
| <i>Pot-ash</i> | . | . | . | . | . | 19,50 |
|                |   |   |   |   |   | <hr/> |
|                |   |   |   |   |   | 97,50 |

It remains for repeated experiments to decide, whether it is merely accidental, that the proportion of the alkaline ingredient, in this instance, is less than usual; or whether this diminution takes place regularly in every leucite, altered by volcanic fire.

( 2. )

In this place I shall, moreover, briefly notice a particular variety of leucite, which occurs at *Ronciglione*. It is found

found of middle-sized, insulated grains, presenting sometimes traces of their original crystalline form. Those grains are whitish, inclining to the isabella-yellow; they are entirely opaque, of an earthy look, and very easily friable. When thus comminuted, they do not yield such a harsh sandy powder, as is obtained from grains of volcanized leucite, but a soft powder resembling argillaceous earth.—It seems, therefore, that they have not suffered any change by the fire; but have rather undergone a high degree of decay, caused by the joint action of water and air; and finally, that, by this alteration, they have been brought near to their complete spontaneous decomposition, or resolution into their component principles.

The stock which I had of them was too small to admit of a complete examination; which, however, I think they deserve, for the purpose of discovering, whether in this state of great decay, they had suffered any loss of that alkaline ingredient, which was before unknown in the mineral kingdom.

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I now flatter myself with the hope, that, by the experiments here communicated, and several times repeated, I have fully demonstrated the existence of pot-ash in the leucite, as one of its chemical constituent parts. Nevertheless, I am contented to defer the general reception of this new discovery till several other chemical naturalists have re-examined and confirmed it. This trial may be the sooner expected, since my method of proceeding in the main object of this investigation is attended neither with laborious operations, nor with much loss of time.

But if that alkali, as soon as it can no longer be considered as a substance, produced only in the juices of plants during their



their vegetation, be required to occupy a more suitable place among the original, simple mineral substances, it will then likewise be necessary to give it a more appropriate name.

The term *Pot-ash*, which, in the new chemical nomenclature, is raised to a *generic* name, cannot among us  *Germans*  claim a general acceptance; as its origin depends on a trivial *etymological* ground, and has been introduced into use merely from this circumstance, that formerly, instead of calcining furnaces, iron *pots* were employed to ignite the inspissated lyes procured from wood-ashes.

I should wish to recommend, that the denominations hitherto used, of *vegetable alkali*, *lixivated vegetable salt*, *pot-ash*, &c. be discarded, and the name *KALI*\* be employed in their stead. In like manner should the appellations, *mineral alkali*, *soda*, &c. denoting the alkaline basis of common salt, give place to its ancient name, —*NATRON*.

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\*) This has been done by the London Royal College of Physicians in the year 1787. They have introduced in their *Pharmacopæia* both these names, *kali* and *natron*, here recommended by *Klaproth*. The *Edinburgh Dispensatory*, on the other hand, calls the first *lixiva*, and the second *soda*.—However, the terms, *pot-ash* and *soda*, being at present more familiar to modern English chemists, the Translator has, for the most part, given them the preference.—Transl.

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## XXXIII.

## CHEMICAL EXAMINATION

OF

*PUMICE-STONE.*

THE *Pumice-stone* belongs to those mineral bodies, on the origin and formation of which the opinions of philosophers are yet divided. Various passages in the works of *Theophrastus*, *Dioscorides*, *Pliny*, and *Galen*, concerning this substance, shew sufficiently, that, even in remoter ages, Naturalists have thought it worth their consideration. One of the principal foundations absolutely necessary to be laid down by the inquiring *Geologist*, if he wishes to raise with success the edifice of his theories, undoubtedly consists in a just and accurate chemical knowledge of his object. This knowledge has, however, been hitherto wanting, with regard to pumice-stone. For, although various analyses of it have been published, there still occurs a very important difference in the enumerations of its constituent parts: so much so, that the Mineralogist is at a loss to know, which of them he is to follow in the arrangement of fossils.

Many of those who have analysed the pumice stone, consider it, with *Bergmann*,\* as an *asbest* changed in its mixture by a volcanic fire. This opinion seemed to be justified, partly by its fibrous texture, partly, and especially,

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\* *Bergmann* Opusc. Phys. et Chemic. vol. III. p. 197.



### XXXIII. Examination of Pumice-stone. 369

by the portion of magnesia, that has been supposed to exist in it. But, notwithstanding that *Bergmann*, *Cartheuser*\*, and but very lately *Spallanzani*†, have mentioned the magnesian earth, in their analyses of pumice-stone, as a constituent part,—I am convinced, by my own experience, that it does not, in the least, enter into this fossil. The supposed origin of pumice-stone from asbest is, therefore, unfounded; and, along with this false derivation, likewise, another difficulty of some weight is removed, which seemed to oppose the instructive theory of the *matrices of pumice-stone* given by *Nose* ‡.

a) Common, grey-white, fibrous pumice-stone, swimming on water, and procured from *Lipari*, was ground, and boiled with water. The water boiled with it was found to have extracted nothing; only, by treatment with nitrated silver, it gave a slight indication of muriatic acid.

Hundred grains of this pumice-stone, gently ignited, and finely pulverized after decoction, were exposed to a red-heat, with twice their weight of caustic alkali, during half an hour. The mass returned from the fire of a bright grass-green colour; by which it was found to contain a small portion of *manganese*. After having been softened with water, this colour changed to a foul light-brown. It was then digested with dilute muriatic acid. *Siliceous earth* separated in this process; which, collected on the filter, and finally heated to redness, weighed  $77\frac{1}{2}$  grains.

b) What had been dissolved by the acid was next precipitated by caustic ammoniac, and the brownish precipi-

\* *Cartheuser*, Mineralogische Abhandlungen, Th. II. p. 136.

† *Spallanzani's Travels into both Sicilies*, vol. II.

‡ *Orographische Briefe*, vol. II. page 185 and others. Also *Sammlung einiger Schriften über Vulkanische Gegenstände a. d. Bay. salt*, page 271.

370 XXXIII. *Examination of Pumice-stone.*

tate collected on the filter. The fluid separated from it, contained no extraneous matter.

c) Hot caustic lye directly dissolved that precipitate, leaving an *oxyd of iron* behind it, the quantity of which, after ignition, was  $1\frac{3}{4}$  grains.

d) The alkaline solution, previously super-saturated with muriatic acid, was combined with carbonated alkali. Thus, the earth which it held dissolved was precipitated. Whenedulcorated, and heated to redness, it weighed  $17\frac{1}{2}$  grains. It proved to be pure *aluminous earth*; for, on being redissolved in sulphuric acid, and combined with an adequate portion of liquid acetated pot-ash, it afforded nothing but alum.

In consequence of this, the constituent parts, discovered in the common *pumice-stone from Lipari*, are:

|                                        |    |           |       |
|----------------------------------------|----|-----------|-------|
| <i>Silex</i> . . . . .                 | a) | . . . . . | 77,50 |
| <i>Alumine</i> . . . . .               | d) | . . . . . | 17,50 |
| <i>Oxyd of iron</i> . . . . .          | c) | . . . . . | 1,75  |
| Besides a trace of <i>manganese</i> a) |    |           |       |

---

96,75

It is worth remarking the small degree of solvent power which acids exert on rough pumice-stone. Although I had digested 100 grains of finely-ground pumice-stone with twelve times its quantity of muriatic acid, assisted by a boiling heat, yet it was hardly attacked. The acid, indeed, was tinged of a faint yellow; however, at most, there appeared only a few loose, brownish flocculi, which, when most carefully collected, scarcely amounted to  $\frac{1}{8}$  of a grain, and consisted, for the greatest part, of oxyd of manganese. The sulphuric acid proved to be as little capable of affecting rough pumice-stone as the muriatic.



## CHEMICAL EXAMINATION

OF THE

*TERRA AUSTRALIS* (*Sidney-earth*).

A few years since, the public has become acquainted with an arenaceous, or sandy fossil, under the name *Austral-sand*, which has been found near *Sidney-cove*, in *New South-Wales*, and was brought from thence to England. This fossil has been asserted to contain a new, distinct, peculiar earth, denominated *Austral-earth* (*Sidneia, Cambria*), upon the ground of its analysis made and published by *Jos. Wedgwood*\*; of which the following are the principal particulars. The principal character of that earth is said to be, that it resists all acid and alkaline menstrua, strong muriatic acid only excepted, which alone, by means of repeated digestion, takes up this earth from that arenaceous fossil. It is also said to be again precipitated from its muriatic solution, merely by dilution with water; and to be, after this, absolutely insoluble in any other solvent but the muriatic acid, with the assistance of heat.

My desire of acquiring information on this subject by my own experience has continued till now unaccomplished. It is only of late that I was fortunate enough to receive a quantity of austral-sand; little, indeed, yet sufficient for an examination sparingly managed. The specimens obtained

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\* *Philosophical Transactions*, vol. lxxx. 1790.

were of two sorts. One of them was mixed with a greater proportion of those black, shining lamellæ, that are taken for graphite, but, to my conjecture, are rather flakes, or scales, of ferruginous mica. The other sort was purer, and had less of the substance just mentioned. For this reason I employed only this in the present inquiry.

a) I triturated *thirty* grains of it to a most impalpable powder. The original grey-whitish colour of that fossil changed thereby to a blueish, owing to a more minute division of the particles of ferruginous mica. Strong muriatic acid was then affused upon the powder, and digested with it for a considerable time, in a heat of ebullition. After cooling, the acid was decanted from the sediment, and this last digested with a fresh quantity of the same acid. This operation was reiterated a third time.

b) When the acid had been filtered clear, through a double-folded printing-paper, I diluted it gradually with a large quantity of water; but not the least turbidness nor precipitation ensued. I exposed the mixture to a warm temperature; yet still it remained clear and limpid, like water.

c) The muriatic liquor was then saturated with carbonate of pot-ash. This threw down a few light particles, which, collected on the filter, washed, and dried, weighed  $3\frac{1}{2}$  grains. They also dissolved in dilute sulphuric acid, but left behind a slight portion of filix, and formed with that acid crystals of alum.

d) The residue left on the extraction with muriatic acid was ignited with three parts of carbonated pot-ash, then again treated with muriatic acid, and its insoluble slimy portion separated by filtration. This last consisted of filix, weighing  $19\frac{1}{2}$  grains, whenedulcorated and ignited.

e) The



e) The muriatic solution was then tried with prussiated pot-ash. The blue precipitate hereby produced indicated about  $\frac{1}{4}$  grain of iron.

f) By combining afterwards the solution with carbonated pot-ash, aluminous earth was precipitated; which, after ignition, weighed  $8\frac{1}{2}$  grains, and, upon solution in sulphuric acid, entirely crystallized into sulphat of alumine.

*Silex*, *alumine*, and a little *iron*, therefore, were all the principles I was able to discover in the austral-sand here examined; and no trace of any other constituent ingredient appeared.

Although in this inquiry I have been obliged to confine myself to the small quantity of 30 grains, without being able to repeat it for want of a greater stock of this mineral, yet its result is sufficient to excite a very reasonable doubt of the *real existence* of such a new earth as is pretended to be met with in austral-sand. Time will shew whether this doubt may be removed, or confirmed, by repeated and more accurate analyses. If the last should be the case, the illusion which led to that erroneous supposition may, perhaps, be explained in the following manner:—

Mr. *Wedgwood* does not tell whether he had filtered, to perfect clearness, the muriatic acid employed for the extraction of the fossil, and *previously* to its being mixed with water. The contrary seems rather to have taken place; for he says that the fluid turned white when he added water to the acid, for the purpose of diluting the acid, and edulcorating its remaining part. It is therefore probable that the earth, let fall by the acid on the admixture of water, was nothing else but alumine still chemically combined with *silex*, which, during the long and hot digestion, had been

taken up by the muriatic acid, and was now deposited in the water.

Finally, that the fossil here examined was *genuine austral-sand*, is warranted by the hand from which I received it. It was Mr. *Haidinger*, from *Vienna*, who kindly gave it me on his return from London, where he obtained it from the Right Hon. Sir *Joseph Banks*, Bart.\*

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\* Since that time *Charles Hatchett*, Esq. F. R. S. of London, has likewise analysed the *terra australis*, and found it to contain *no new earth*, but to be a compound of *filex*, *alumine*, *oxyd of iron*, and *plumbago*. His paper is printed in the *Philosophical Transactions* for the year 1798.---Transl.



XXXV.

## CHEMICAL EXAMINATION

OF THE

GRANULAR SULPHATED BARYTES.

*From Peggau.*

THE *granular baroselenite*, or *sulphat of barytes*, is one of the rarer species of this genus of ponderous earth. That of *Peggau*, in *Stiria*, which is the subject of this essay, occurs of a beautiful milk-white colour, is massive, resplendent, finely-grained, semi-indurated, and brittle. It bears a very strong resemblance to the white, fine-grained *Carara-marble*; to such a degree, that, by its mere appearance, it might easily be mistaken for it, were it not for its greater specific gravity, which is 4,380, and by which it is readily distinguished.

A.

- a) It loses nothing of its weight by ignition.

b) When pulverized, and boiled with a large quantity of water, it imparts to this last nothing observable by the sight, taste, or smell. Of all the re-agents, only the solution of silver in nitric acid rendered the water boiled with it in a slight degree opalescent.

c) In like manner, nothing of it was dissolved by digestion with muriatic acid. The only exception from this is an unimportant trace of iron, which was detected by Prussian alkali.

## B.

- a) Two hundred grains of this fossil, mixed with 500 grains of carbonated pot-ash, were subjected, for two hours,

hours, to a moderately strong red-heat. The mass, which only conglutinated, was then pulverized, boiled with water, and the remaining earth collected upon the filter.

b) The alkaline fluid contained some siliceous earth, besides the *fulphuric acid of the barytes*. To separate that earth, the fluid was fully neutralized by muriatic acid, and evaporated to dryness. The *silix* remaining, after the resolution of the saline mass in water, weighed 18 grains upon ignition.

c) The barytic earth freed from the sulphuric acid (b) was covered with water, and combined with muriatic acid. After some digestion, the whole was found dissolved, except a remainder of *siliceous earth*, of two grains weight, when ignited. When this last had been separated, I caused the filtered solution to crystallize, by the usual management; and it afforded, to the end, only muriat of barytes, partly in rhomboidal, partly in oblong six-sided tables.

d) All these crystals I dissolved again in water, and dropped sulphuric acid into the solution only as long as it produced any precipitate. The regenerated *fulphat of barytes*, when collected, washed, and dried, weighed 185 grains; but, when heated to redness, no more than 180 grains.

The mixture of this fossil, in one hundred parts, therefore, consists of :

|                            |       |          |
|----------------------------|-------|----------|
| Pure fulphat of barytes d) | . . . | 90       |
| Silix . . . . . b) 9 }     |       | . . . 10 |
| — . . . . . c) 1 }         |       |          |

---

100

Or,



*of the granular sulphated Barytes.* 377

Or, because in the ignited ponderous spar, or sulphat of barytes, the *earth* is to the acid very nearly in the proportion of 2 to 1, the above fossil consists of:

|                                         |       |
|-----------------------------------------|-------|
| <i>Barytes</i> . . . . .                | 60    |
| <i>Sulphuric acid</i> (free from water) | 30    |
| <i>Silex</i> . . . . .                  | 10    |
|                                         | <hr/> |
|                                         | 100   |

## CHEMICAL EXAMINATION

OF THE

## TESTACEOUS SULPHAT OF BARYTES,

*From Freiberg\*.*

IT was, undoubtedly, the powerful attraction which the barytic earth has for sulphuric acid, exceeding even that of the pure fixed alkalis, that induced the deserving *Scheele*, who first discovered it as a distinct earth, to think that an alkaline salt is incapable of resolving the natural mixture of baroselenite into its separate principles. On this account, when attempting to expel its sulphuric acid, he resorted to the imperfect and tedious process of repeatedly working the stone to a paste, with honey or oil, of calcining that mass by means of the muriatic or nitric acids, and, at last, of extracting such a part of it as had been disengaged from the sulphuric.

Yet there are several instances where the unassisted force of attraction of pure alkali has been too weak to separate

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\* *Chemisch. Annal.* 1796. I. B. S. 387. It is, properly, a variety of common *ponderous spar*. *Kirwan* calls it *Baroselenite*. The author, with the rest of the *Germans*, and some *French*, calls it (*schalig*) *testaceous*, from its form, pretty equally spreading in length and breadth, but, comparatively, of inconsiderable thickness. *Emmerling* has given a masterly detailed description of its figure and varieties. See his *Lehrbuch der Mineralogie*, Gießen 1793. Vol. I. page 557. seq. --- Transl.



the component principles of mixed bodies; while, on the contrary, when they have been employed in the carbonated, or otherwise neutralized state, the desired object has been attained by this new increase of attractive force.

This is the very case with ponderous spar, and is founded on the method learnt of *Wiegleb*: which is, to decompose it in a shorter, cleaner, and more complete manner, by igniting it with carbonat of pot-ash. This method, as to the most essential part, has since been universally approved and adopted.

It seems, however, to be the common opinion, that this decomposition obtains, in the *dry way* only, and that the separation of sulphuric acid from barytes absolutely wants the support of red-heat; as, to my knowledge, no one has yet attempted the *humid way*, to effect it.

A.

a) A thousand grains of common, white, thick, testaceous baroselenite\*, in the purest selected pieces from the mine *Kurprinz Frederick August*, near *Freiberg* (in Saxony), were triturated with water to the finest powder, and then boiled for one hour, in a silver pan, with twice their weight of carbonated pot-ash, and five of water, stirring them occasionally, and supplying the loss of water as it evaporated; which being done, more water was added, and the whole filtered. The residue weighed 910 grains, after washing and exsiccation. Muriatic acid was affused upon it successively, until all effervescence ceased. After gentle di-

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\* Thick-testaceous (*Dickschalig*), when from  $\frac{1}{4}$  to  $\frac{1}{2}$  an inch thick.—Transl

gestion,

gestion, the muriatic acid was filtered off from the still undecomposed barytic sulphat, which, upon washing and drying, weighed 426 grains.

b) With this remainder of sulphated barytes, the same process of coction with double its quantity of carbonated pot-ash, and five times that of water, was repeated.—The edulcorated powder amounted to 387 grains; of which, after extraction of the soluble part of earth by muriatic acid, there remained 198 grains still undecomposed.

c) These 198 grains, treated in the same manner with alkali and water, gave then 183 grains. Of these, the muriatic acid left again 128 grains of undecomposed sulphat of barytes.

d) When these had been boiled with pot-ash and water, in the manner mentioned before, there remained 122 grains; which muriatic acid dissolved, excepting a remainder of 96 grains.

e) After a new subsequent decoction with twice the quantity of alkali and water, there remained 90 grains; of which, upon extraction performed with muriatic acid, there appeared a residue of 72 grains; which,

f) Upon repeating the boiling with carbonic pot-ash, left 69 grains of powder, and, after extraction by muriatic acid, 61 grains.

g) As I thus observed that the success of the decomposition of ponderous spar decreases in the proportion of its diminished quantity, I had recourse to the *dry way* for the final analysis of that residue. For this purpose I mixed it with three times its weight of mild alkali, or carbonated  
pot-



pot-ash, calcining the mixture in a silver-vessel during the space of half an hour. After softening the mass, there remained 50 grains of edulcorated residue; which now totally dissolved in muriatic acid, only five grains of unattacked *flex* excepted.

The alkaline lixivium, obtained from that ignited mass, and somewhat reduced by evaporating, then afforded three grains of *siliceous earth*.

b) I then evaporated, together, all the muriatic solutions mentioned before, to the point of crystallization; and they yielded, at the first two shootings, the muriated barytes in a perfectly pure state.

i) The remaining solution seemed to exhibit signs of the presence of some iron. It was therefore saturated with caustic ammoniac, and filtered. There collected on the paper a brownish earth, which, when highly dried, weighed  $1\frac{1}{2}$  grain. Yet, notwithstanding this small quantity, it was not mere oxyd of iron; for, when dissolved in muriatic acid, and treated by Prussian alkali, the fluid remaining, after the separation of the blue precipitate, yielded half a grain of *alumine*, by combination with ammoniac. The portion of iron, therefore, amounted only to one grain.

k) The remainder of the solution of muriated barytes, being thus freed from those foreign ingredients, was decomposed by means of mild ammoniac. I then re-dissolved the precipitated earth in muriatic acid, and put it in a gentle temperature for farther crystallization. Pure muriat of barytes crystallized, as long as the solution contained one drachm of it; upon which I committed it to spontaneous exhalation in the open air. It crystallized entirely, without leaving any drop of liquor, to regular crystals; of which

which the first shooting still consisted of some tables of muriated barytes, but the subsequent ones afforded needle-shaped crystals of muriated strontian-earth.

l) Upon this, I carefully collected the crystallized muriat of strontian, dissolved it again in water, and re-produced it again in its former state of *sulphated strontian-earth*, by dropping sulphuric acid into the solution. The sulphat, washed and dried, weighed  $8\frac{1}{2}$  grains.

m) The whole of the crystallized muriat of barytes, which was collected, amounted to 18 drachms.

n) Another portion of a thousand grains of sulphated barytes, ground to a moderately fine powder, and subjected to intense red-heat for half an hour in a porcelain-crucible, lost no more than seven grains of their weight; which loss may probably have consisted only of the *aqueous particles* driven out in the process.

It results from these experiments, that the *white, testaceous sulphat of barytes*, in pieces selected of the utmost purity, and from the mine mentioned above, reckoning with a thousand parts, is composed of:

|                          |           |       |
|--------------------------|-----------|-------|
| <i>Sulphated barytes</i> | . . . . . | 975   |
| — <i>Strontian-earth</i> | . . . . . | 8,5   |
| <i>Silex</i>             | . . . . . | 8     |
| <i>Oxyd of iron</i>      | . . . . . | 1     |
| <i>Alumine</i>           | . . . . . | 0,5   |
| <i>Water</i>             | . . . . . | 7     |
|                          |           | <hr/> |
|                          |           | 1000  |



B.

The result of this analysis, therefore, demonstrates, that the *humid way* is likewise applicable in the decomposition of ponderous spar, by means of alternate boiling with a concentrated aqueous solution of carbonated pot-ash, and subsequent solution in any suitable acid.

This management affords, especially in operations performed with great quantities, a double advantage. The *first* is, the saving of crucibles, which would be otherwise destroyed; the *second* is this, that the remaining alkali, which ought to be recovered after the separation of the newly-formed neutral sulphat, is not liable to be contaminated in this method.

When ponderous spar is ignited or fused with pot-ash, that part of the alkali which is not neutralized, during the process, by the sulphuric acid of the fossil, will attack not only the siliceous and argillaceous earth, which are usually contained in the ponderous spar, but also that which enters into the substance of the crucible. It will also retain a great part of those earths, in a dissolved state, in proportion as the alkali, during ignition, gives out its carbonic acid, and becomes more or less caustic. On the contrary, if the process of boiling be employed, no transition takes place in the alkali, from the mild or carbonated, into the caustic or pure state; hence also no contamination of it with filix and alumine will arise.

## XXXVII.

## CHEMICAL EXAMINATION

OF THE

*CROSS-STONE (Staurolite.)*

THE chemical analysis of that fossil, which is found at *Andreasberg*, on the *Harz*, and has the name of *cross-stone*, *cross-crystal* (*staurolithus*), and consists of double crystals, concentered in the form of a cross, has already been instituted by two eminent chemists, *Heyer* and *Westrumb*. Both have long ago published their analyses. It might therefore be deemed needless to add mine, if the following reasons did not excuse it.

It is well known, that both these chemists have found *barytes*, besides *silica* and *alumina*, among the constituent parts of that fossil. To suppose the presence of *barytes*, in this instance, *Westrumb* was satisfied with the observation, that, by combination with sulphuric acid, this earth forms a precipitate of difficult solution in water. From the state of chemical knowledge of the simple earths at that time, it was indeed allowable, to consider such a precipitate, directly and without trial, as sulphated *barytes*.

But since we have become acquainted with *strontian-earth*, which likewise combines with sulphuric acid to a difficultly soluble precipitate, that phenomenon alone is not sufficient to determine, whether a certain earth, met with in any process, be the *barytic*.

*Heyer,*



*Heyer*, on the contrary, when examining the *staurolite*, found this constituent part of it to crystallize both in the nitric and muriatic acids; from which he could, with greater confidence, suppose it to be of a barytic nature. But, as he has given no particular account of the figure of its crystals, especially of those formed with the muriatic acid, I thought that a fresh examination of this fossil might be a means to ascertain, whether the earth mentioned was really the barytic, or whether the *strontian*.

a) One hundred grains of white crystals of the cross-stone, carefully freed by distilled vinegar from all adhering calcareous earth, were finely pulverized, and subjected to a low red-heat for half an hour, with a double quantity of carbonated pot-ash. The mass, which was then easy of trituration, was lixiviated with water, and left 109 grains behind.

b) To this residuum was added the small portion of earth, which was still obtained from the alkaline lye, by saturating it with an acid, and evaporation. I then gently digested it with muriatic acid, with which it effervesced, and deposited *siliceous earth*, in a fine, sandy form, weighing 32 grains, after previous separation by the filter, and ignition.

c) The muriatic solution, super-saturated with caustic ammoniac, gave a transparent, paste-like precipitate, which, uponedulcoration, drying, and ignition, weighed 33 grains. It consisted of alumine, but still mixed filix. For this reason, I combined it with sulphuric acid, and evaporated it to a moderately dry saline mass, which, again diluted with water, deposited *siliceous earth*, amounting to 17 grains, when heated to redness. The true quantity of aluminous earth, therefore, amounted to 16 grains.

c c

d) The

386 XXXVII. Examination of Staurolite.

d) The remaining solution was evaporated to a smaller volume, and the earth, which it still contained, was precipitated by means of carbonated pot-ash. This earth weighed 23 grains, when washed and dried. But when re-dissolved in muriatic acid, it shot, to the last drop, into tabular crystals of muriated barytes: proving, by this, to be *true barytic earth*.

e) Since, in consequence of other experiments, those 23 grains of carbonated barytes are equal to 18 grains of *pure barytes*; since, moreover, the staurolite lost 15 per cent of the whole, on ignition, and, as this loss was probably mere water, the proportion of its constituent parts is as follows:

|                |   |   |   |    |   |    |   |   |   |   |   |         |
|----------------|---|---|---|----|---|----|---|---|---|---|---|---------|
| <i>Silex</i>   | . | . | . | b) | . | 32 | } | . | . | . | . | 49 grs. |
|                |   |   |   | c) | . | 17 | } |   |   |   |   |         |
| <i>Barytes</i> | . | . | . | e) | . | .  | . | . | . | . | . | 18      |
| <i>Alumine</i> | . | . | . | c) | . | .  | . | . | . | . | . | 16      |
| <i>Water</i>   | . | . | . | e) | . | .  | . | . | . | . | . | 15      |
|                |   |   |   |    |   |    |   |   |   |   |   | <hr/>   |
|                |   |   |   |    |   |    |   |   |   |   |   | 98 grs. |



## XXXVIII.

## SOME FARTHER RESEARCHES

## CONCERNING

*WITHERITE and STRONTIANITE.*

## FIRST SECTION.

## A.

IT is needless to prove, that chemical analyses give more accurate results, the greater the quantity is of the substance subjected to decomposition. But, at the same time, it is not less evident, that the expence of the process increases in the same proportion. The chemist, therefore, who, besides time, trouble, and patience, frequently sacrifices a considerable sum to his love for the science, should not be censured for parsimony, if he can but seldom perform his analytical experiments with ounces and pounds, but must commonly restrain himself to smaller quantities.

The following researches on *witherite* may afford an instance of what just now has been said.

a) Twelve ounces of *witherite* from *Anglezark*, (near *Chorley*, in Lancashire) coarsely powdered, were gradually dissolved in fifty ounces of a mixture, composed of one part of muriatic acid and three of water. Except a few grains of sand, no residue was left. The filtered solution, when set to crystallize, gradually afforded 14 ounces  $5\frac{1}{2}$  drachms of *muriated barytes*.

c c 2

b) The

b) The mother-water, remaining from that solution, had acquired a greenish colour; and, as likewise the crystals which last formed, seemed to tend a little to the green, I desiccated them in a high heat, washed them with alcohol, and added the washings to the remaining fluid; which I then treated with caustic ammoniac, added to excess of saturation. By this management, the solution was rendered sky-blue, and, at the same time, turbid, by a slight portion of earth which then separated. This last, collected, and dried in the air, weighed  $2\frac{1}{2}$  grains; had a yellowish-white colour, and was *aluminous earth, mixed with iron*.

c) On super-saturating the filtered fluid with muriatic acid, the blue colour disappeared. I then treated it with prussiat of pot-ash of the utmost purity. This produced a brown-red, tender precipitate, which I carefully gathered, washed, and desiccated. But this, besides that it was of so small a quantity, had so firmly adhered to the filtering paper, that it could not be accurately separated from it. It was, therefore, together with the paper, subjected to low-red heat, and the ashes were extracted by liquid carbonat of ammoniac, until the portions of this, successively employed, ceased to be tinged blue. When upon this, the volatile-alkaline tincture had been evaporated, there remained in the evaporating pan a bright-green, carbonated *oxyd of copper*, weighing half a grain; which dissolved in a few drops of dilute sulphuric acid, and immediately precipitated, in the reguline state, on a polished piece of iron, upon which it was dropped.

d) The mother-water of the solution of the witherite (b), previously purified with caustic ammoniac and Prussian alkali, was next combined with mild alkali prepared from tartar; and the precipitate, that appeared of a dazzling white, being dissolved in muriatic acid, was left to spontaneous



neous exhalation. Thus the solution constantly afforded muriat of strontian-earth, in small hexahedral crystals; which, re-dissolved in water, and precipitated by carbonat of ammoniac, yielded 98 grains of carbonated strontian-earth.

These 12 ounces of witherite, which are equal to 5760 grains, consisted, therefore, of:

|                                                                    |           |
|--------------------------------------------------------------------|-----------|
| Carbonated barytes . . . . .                                       | 5659 grs. |
| Strontian-earth . . . . .                                          | 98        |
| Carbonated oxyd of copper . . . . .                                | 0,50      |
| Alumine, contaminated with iron,<br>and dried in the air . . . . . | 2,50      |
|                                                                    | <hr/>     |
|                                                                    | 5760 grs. |

The foregoing analytical process serves to confirm the existence of a slight trace of copper in the English witherite, which has been already observed by *Westrumb*\*, as well as the presence of strontian-earth, both in the English and Siberian witherite, noticed by *Lowitz*†.

B.

Hitherto, the only places where carbonated barytes is found native, are *Anglezark*, in England, and the *Schlangenberg*, in Siberia; for, the report of its occurrence in the metalliferous mountains of Saxony has not yet been confirmed. However, this fossil has of late also been discovered in a third place, which is the pit *Steinbauer*, near

\* *Chemische Abhandlungen, von Westrumb*, Hanover, 1793, vol. I. page 266.

† *Chemische Annalen*, 1793. I. Band. Seite 110.

*Neuberg*, in Upper-Stiria. It is found there in a stratum of spatose iron-stone, partly massive, or in considerable lumps, and in part coarsely disseminated in brown iron-ochre.

One hundred grains of this *Stirian witherite* dissolved completely, and with effervescence, in dilute muriatic acid. The whole of that solution shot into muriat of barytes, in tabular crystals; the aqueous solution of which was precipitated in the state of sulphated barytes, by means of sulphuric acid.

## SECOND SECTION.

### A.

THE attempts made to free *witherite* from its portion of carbonic acid, simply by ignition, and to bring it thus to the perfectly caustic state, have hitherto miscarried, owing to its vitrifying with the mass of the clay-crucibles; and, on the other hand, its consuming, and, as it were, dissolving, those made of charcoal. On this account, I resolved to repeat the experiment with a vessel made of platina.

A piece of *witherite*, weighing 200 grains, was put in a platina crucible, previously weighed, and this last, when introduced into a saggar (*caffette*) made of clay, was conveyed into the middle chamber, or fire-place, of the porcelain-furnace; where the intensity of heat is at 136 degrees of *Wedgwood's pyrometer*. When the vessel had returned from the fire, I found the weight of its contents diminished  $23\frac{1}{2}$  grains. The calcined *witherite* appeared as a dirty-brownish, coarse powder; which so firmly adhered to the bottom of the crucible, that it could not be detached without injuring the latter. I, therefore, tried whether I could soften the calcined *witherite* with water. But, although



though the water affused upon it became intensely heated, the separation of the stone proved so difficult, as to oblige me to assist it by a boiling heat. The calcined witherite left at the bottom of the platina crucible some flosculous impressions; and, in general, its internal polish suffered much, though the external remained unimpaired.

The loss of weight, amounting to  $11\frac{1}{4}$  per cent, indicated that the witherite had not lost much above one half of its carbonic acid. It was owing to this, that it would not entirely dissolve in boiling water, and that the residue still considerably effervesced with acids.

In the filtered aqueous and clear solution of the calcined witherite, which had been directly preserved in a well-stopped bottle, I observed, after some days, that the barytic earth had crystallized in several small groups, between which various insulated crystals formed distinct octahedrons. In order to obtain a greater quantity of them, I reduced, by boiling, all the water impregnated with the ignited barytes to one fourth part; separated by filtration the pellicle of carbonated barytes, which formed on the surface of the fluid during the process; and transferred the liquor, while yet hot, into a glass provided with a stopper. Before the water had thoroughly cooled, similar crystals were formed, which I found considerably increased on the following day. Thus I saw with pleasure confirmed by my own experiments the fact, that calcined barytes is crystallizable in water; which property *Vauquelin* and *Pelletier* have of late, each in a different way, discovered at Paris.

B.

Since, therefore, according to this last experiment, the barytic earth agrees in this point with the strontian, it fol-

c c 4

lows,

lows, that this property of any calcined earth to crystallize in mere water can no longer be considered as an exclusive character of *strontian-earth*. But from this we can by no means conclude, that both these earths are *identically* the same. Their essential difference, besides the other discriminating properties already known, principally depends on the specifically different degrees of affinity, or chemical attraction, shewn by each of them for the various acids. Of this, the following experiment furnishes a proof.

I mixed an aqueous solution of acicularly crystallized muriated *strontian-earth* with a solution of *acetated barytes*; evaporated the mixture to dryness; exposed the obtained saline mass to a strong red-heat in a crucible; re-dissolved that ignited residue in water; promoted the crystallization of the filtered solution by the usual means, and obtained only *muriated barytes*, crystallized in quadrangular tables,

The muriatic acid, therefore, quitted the *strontian-earth*, and combined with *barytes*, with which it had a stronger affinity.—By this new demonstration of the essential difference of these two earths, deduced from the different degrees of their attractions for acids, it may be hoped, that chemists will no longer entertain any doubts concerning the existence of the *strontian* as a distinct earth.

## C.

Before I conclude, I shall yet notice, in a few words, the relations of *barytes* to *prussiat of pot-ash*. The precipitation, effected by this last, of *barytic earth* from those acids with which it forms soluble middle salts, has several times occasioned erroneous conclusions. It was upon this, that *Bergmann* and others have founded their hypothesis, ascribing a metallic nature to that earth, already refuted by more accurate



rate examinations. With no better reason, has even lately one of the principal French chemists\* reckoned the precipitation of barytes by Prussian alkali among the characters which distinguish it from strontian earth.—However, this precipitation does not take place, except when the prussiated pot-ash employed is not entirely free from the neutral sulphat, which usually contaminates it; for, if the prussiat is perfectly pure, it is as little capable of precipitating barytes as any other of the simple earths. On this account, whenever I prepare Prussian alkali, to be used in accurate chemical experiments, I always repeat the processes of its purification, until the solution of nitrated barytes is no longer, even in the least degree, rendered turbid by it.

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\* Journal des Mines, N. xxi. Prairial, p. 45. seq.

CHEMICAL EXAMINATION  
OF THE  
*SULPHATED STRONTIANITE*  
*from Pennsylvania\*.*

AFTER the strontian-earth had been established as a peculiar, chemically-simple earth, it was to be expected, that it might likewise occur combined with *sulphuric acid*, instead of the *carbonic*, as is the *strontianite* from Scotland. This conjecture was already in part verified; as it has been found, that most of the ponderous spars contain sulphated strontian-earth in their mixture, though in only a small proportion, not amounting in the baroselenites, hitherto examined with this view, to more than from one to two *per cent.*

But the present analysis will fully prove the existence of a perfect *natural sulphat of strontian-earth*, without any portion of barytic ingredient.

The fossil, in which I discovered this combination, has been known but a few years. It was at first called, *blue, fibrous gypsum, from Frankstown, in Pennsylvania.* The following are its distinctive characters.

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\* Sulphat of strontian-earth (*strontites*) has also been discovered lately in the beach at *Aust-passage*, near *Bristol*, in Gloucestershire, in several veins. This fossil has been analysed by *William Clayfield*. See *Contributions to Physical and Medical Knowledge*, &c. collected by Dr. *Beddoes*.—Transl.



Its colour is a pale sky-blue. It occurs in flat layers, or strata, from  $\frac{1}{2}$ ,  $\frac{1}{2}$ , to  $\frac{5}{8}$  of an inch thick, included between two even sides; which last partly appear to be real seams, or joints (*saalbänder*), and, partly, are mere separating surfaces, formed by small clefts of the rock, filled with clay. On these exterior sides the fossil has a dull appearance; but, internally, it is possessed of the ordinary lustre. It is easily comminuted, and consists throughout of coarse, parallel, brittle fibres, which form needle-shaped fragments.

The specific gravity of this fossil I found to be 3,830. This considerable weight naturally suggested a doubt of its belonging to the species of gypsum. For this reason, it has been considered as a variety of ponderous spar, and placed in the mineralogical system in the character of *fibrous sulphat of barytes*. This, however, is not more its proper place, than that of gypsum, or sulphat of lime.

## A

a) *Hundred* grains of the fossil, finely pulverized, were boiled in one pound of distilled water; whereby it lost three grains. The water of the decoction was rendered turbid by mild alkalis, by oxalat of pot-ash, by the nitrated solution of silver; but, most of all, by muriated barytes.

b) The powder, when again dried, was treated with muriatic acid; which, a trace of iron excepted, extracted nothing that was observable.

## B.

a) I ignited *two hundred* grains of such pieces of the fossil as were pure, and free from the grey argillaceous matter,

matter, that crosses it in thin fissures. It lost by this about one grain in weight; and the blueish colour passed into the light isabella-yellow. It was next triturated, then mixed with 500 grains of carbonated pot-ash, and the mixture exposed in a silver pot to a moderate red-heat, during the space of three hours. The mass became grey, strongly coalesced, and nearly entered into fusion. Upon this, I pulverized it, boiled it with water, and collected the earth upon the filter.

b) The alkaline lixivium was super-saturated with muriatic acid, evaporated to dryness, and the saline mass softened again with water, and neutralized with alkali. As by this treatment no separation of earth was observable, I saturated again the lixivium to excess with muriatic acid, and combined it with muriated barytes. In this way I obtained 254 grains of *barytic sulphat*, which, upon ignition, weighed 250 grains.

c) That earth, which remained after the decoction of the saline mass that had been fused with the alkali (a), was combined with dilute muriatic acid, which readily attacked, and dissolved it entirely, with effervescence. Caustic ammoniac, added to the colourless solution, clarified by filtering, threw down the small portion of iron which it contained in scarcely perceptible brownish flocculi. The solution being thus freed from iron, I precipitated its earthy portion by carbonated ammoniac, assisted by heat.

d) The earth hereby obtained was very white, tender, of a moderate gravity, and weighed 164 grains in its dry state. It was again dissolved in muriatic acid, and the solution made to crystallize by gentle evaporation. It gradually, and entirely, shot into long needled crystals of six unequal surfaces; which middle, or earthy salt, proved, upon trial, to be mere *muriat of strontian-earth*. A little of this salt,



salt, brought into contact with the wick of a burning candle, gave to the outer flame a highly beautiful carmine-red; and a solution of it in moderately strong spirit of wine burned with the same colour, when cotton, or printing paper, dipped into it, was set on fire.

Hence it appears, from this analysis, that the above fossil, with the exception of its trifling portion of iron, consists solely of *sulphated ironian-earth*.

C.

I repeated this analysis in a shorter way: by boiling with alkaline lye, without previous ignition.

a) One hundred grains of the fossil, ground to a most subtle powder, were mixed with a triple quantity of carbonated pot-ash, covered with six ounces of water, made to boil, and kept in that state during half an hour.

b) The lixivium, filtered off from the remaining earth, was saturated to excess with muriatic acid, in which state it continued clear; and was then combined with successive portions of muriated barytes, till no more precipitate ensued. The *sulphat of barytes*, thus produced, weighed 126 grains after washing and drying, and 124 after ignition.

c) The earthy part of the fossil, which had been disengaged from the sulphuric acid by boiling with alkali, and had in its stead taken up carbonic acid, weighed 82 grains. Muriatic acid dissolved it entirely, and with rapidity, leaving only a few brown particles behind. The filtered solution was first treated with an over-proportion of caustic ammoniac, and, when no longer rendered turbid by it, was precipitated by mild, or carbonated pot-ash.—It gave again

### 398 XXXIX. Of Sulphated Strontianite, &c.

again its former weight of carbonated strontian-earth; namely, 82 grains, when dried in the air. When heated to redness, it formed a moderately conglutinated mass, and occupied only one half of its former volume; yet it did not lose an entire grain in weight. After trituration, though previously ignited, it dissolved rapidly, and with effervescence, in muriatic acid; and gave, by this combination, muriated strontian-earth, in long, thin columns, of six unequal lateral surfaces.

Hence, the result of this decomposition in the humid way, accomplished so completely, and with so much ease, most exactly corresponded with that of the preceding.

Now, since previous experiments have shewn, that 126 parts of barytic sulphat contain 42 of real sulphuric acid, or without water; and since 82 parts of carbonated strontian-earth contain 58 of pure strontian-earth, the proportion of the ingredients constituting the Pennsylvanian, blue, fibrous, sulphated strontianite is accordingly:

|                             |           |    |
|-----------------------------|-----------|----|
| Strontian-earth             | . . . . . | 58 |
| Real sulphuric acid         | . . . . . | 42 |
| Oxyded iron, a slight trace |           |    |

---

100

By these analytical experiments it is fully proved, that I was not mistaken, when I suspected this fossil to be a sulphat of strontian-earth. In forming that conjecture, I was chiefly determined by its specific gravity, which is considerably less than that of ponderous spar; and, likewise, by its fibrous texture: for, even the artificial combination of strontian-earth with sulphuric acid, effected by dissolving that earth in this acid, crystallizes into needles, resembling the fibres of the fossil, though smaller and more delicate.

XL.



## CHEMICAL EXAMINATION

OF THE

*WATER OF THE BOILING SPRING,**at RYKUM, in Iceland\*.*

CONSIDERING the slowness, with which the knowledge of the chemical properties of even the most common natural bodies usually advances, it is not surprizing, that even those of *siliceous earth* have so long remained but partially investigated. This earth has always been considered as a substance, by itself, absolutely insoluble in water. It was, therefore, totally neglected in *hydrologico-chemical* inquiries, or researches into mineral waters, until *Bergmann* directed the attention of chemists to its solubility in simple water, and demonstrated that it exists in a state of solution in the Geyser, and other boiling springs of Iceland.

But although, in this instance, this celebrated philosopher justly considers the heat, which the water of those springs possesses when it rises into day, (and which even then is higher than that of ordinary boiling), as a means of promoting the solution, yet experience has shewn, that an actual solution of *silix* in water takes place, not only in springs, the natural temperature of which is much inferior to the ebullient heat of those in Iceland, but also in several other mineral waters: and even that some common sweet-water springs contain dissolved *siliceous earth*.

Thus, when I was attentive to this point, whilst analysing the mineral waters of *Carlsbad\**, I found that 1000 cubic inches of the main spring contain 25 grains of *silix*, actually dissolved.

\* Read in the *Royal Academy of Sciences at Berlin*, August 28, 1794.

That this is not the greatest quantity of siliceous earth soluble in water, and that, especially, the hot springs in Iceland might possibly contain a much larger proportion of it, I was led to conjecture from the *siliceous tufas* which they deposit in considerable quantities. At that time, however, a proof of this opinion, supported by chemical investigation, was still wanting. It gave me, therefore, the greatest pleasure, when I received a sufficient quantity of water of one of the principal Icelandic springs, which enabled me to perform this inquiry, and to compare its result with that of the analysis of Carlsbad water.

In modern times, *Uno von Troil*, and after him, *Banks* and *Solander*, have particularly deserved well of the Natural History of Iceland, so remarkable in several of its individual subjects, some of which are *unique* in their kind. The latest voyage to that island, undertaken for the purposes of Natural History, is that of *Stanley*, in the year 1789. This learned traveller, (who has given in the papers of the Royal Society of *Edinburgh* a circumstantial description of the spring at the Geyser), when collecting the natural products of that spot, had likewise providently brought back with him a number of bottles filled with the water of those ebullient springs.—Two of these, that came to my hands, served for the following analysis.

The water contained in both bottles is from the spring at *Rykum*. From this spring, 24 English miles distant from *Hafniford*, the water rushed formerly out to the height of 60 or 70 feet. But since the orifice of the spring has been covered, for the greatest part, by an overthrow of the rock, the stream of water, at present, spouts off sideways, from 50 to 60 feet. The heat of this spring, even after the jet,

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\* See p. 274 of this work.



is still so intense, that Fahrenheit's thermometer rises to  $212^{\circ}$ . Therefore, as it is beyond a doubt, that part of the heat is lost during the spouting, and, consequently, that the water must have been some degrees hotter in its subterraneous reservoirs; Nature affords us here an instance, in the large way, of what Art performs in the small, by Papin's digester: namely, that confined water, even while in its unelastic, dense, liquid state, is capable of acquiring a degree of heat, surpassing that of its boiling point.

The water, in both bottles, was clear, bright, without sediment, and without taste. Yet, at the spring itself, it shewed some sulphureous ingredient, according to *Stanley*. For, when employed fresh from the spring, it gave to the infusion of tea prepared with it, as well as to the meat boiled in it, a nauseous taste; whereas, the water from the spring at the Geyser, used in the same manner, gave no sign of it. But as, in the water which I examined, I could not discover any sulphur, either by the taste, by the smell, or by re-agents, it remains undecided: whether this effect proceeded from a portion of highly volatile, sulphurated, hydrogen gas, only observable at the spring itself, or whether, perhaps, the smell produced by putrescent, organic substances has not been mistaken for it; which last is not seldom the case, with various waters, supposed to be hepatic.

On employing other re-agents, it appeared, that this water from *Rykum* contains neither free carbonic acid, nor iron, nor lime, nor magnesia; and that *carbonated, muriated, and sulphated soda*, are to be expected.

Guided by these previous indications of the constituent parts of this water, I performed its analysis in the following manner.

n d

I evaporated



I evaporated a *hundred cubic inches* of it in a gentle sand-heat. When this quantity had been reduced to a remainder of about six cubic inches, I found it coagulated to a pale-brownish, stiff, somewhat turbid jelly. This evidently shewed, that this water had contained a considerable portion of dissolved siliceous earth, which now appeared in its usual gelatinous form. After the evaporation had been carried on to perfect dryness, the powder which was left weighed  $25\frac{1}{2}$  grains.

To separate the *siliceous earth* from this residue, previously to the subsequent operations, I poured water upon it, and when softened, I threw it upon the filter, washed the separated earth, and exposed it to a moderate temperature, to dry. It appeared in a delicate, loose, pulverulent state, and weighed nine grains. To discover whether it was pure, or mixed with any other soluble earth, I digested it with muriatic acid; but when this was again filtered off, it contained nothing extraneous, except a trace of *aluminous earth*, hardly worth noticing.

Hence, the salts still held in solution, deducting the nine grains of filix, amounted to  $16\frac{1}{2}$  grains. Concentrated acetic acid was then dropped into the liquor to the over-saturation of the soda; and when the mixture had been evaporated to dryness, I separated, by highly rectified alcohol, the acetite of soda thus produced, and found the weight of the residue, again desiccated, to be  $13\frac{1}{2}$  grains. From this it followed, that the ingredient, *carbonat of soda*, reckoned in its dry state, amounted to three grains; which are equal to eight grains of crystallized mild soda.

Those  $13\frac{1}{2}$  grains, which yet remained, were liquefied in a little water, and the solution left to spontaneous evaporation. It gave crystals of *muriated* and *sulphated* soda. To find the proportion of these two salts to each other, I re-dissolved



re-dissolved the mixture in water, and decomposed it: first by acetated barytes, and then by nitrated silver. - Calculating afterwards the quantities of the precipitated sulphat of barytes, and muriat of silver, upon the basis of other comparative experiments, I found, that in those  $13\frac{1}{2}$  grains were contained  $8\frac{1}{2}$  grains of *common salt*, and five grains of *Glauber's salt*, reckoned in its dry state, or 12 grains, if crystallized.

According to this, the above  $25\frac{1}{2}$  grains of salt, afforded by 100 cubic inches of water from the boiling spring at Rykum, when deprived of their water of crystallization, or in the desiccated state, consist of:

|                                             |        |
|---------------------------------------------|--------|
| <i>Carbonat of soda</i> (natron) . . .      | 3 grs. |
| <i>Sulphat of soda</i> (Glauber's salt) . . | 5      |
| <i>Muriat of soda</i> (common salt) . . .   | 8,50   |
| <i>Siliceous earth</i> . . . . .            | 9      |
|                                             | <hr/>  |
|                                             | 25,50  |

Shortly after the conclusion of the foregoing analysis, I found in the *Annales de Chimie, Paris, 1793*, that a similar examination had been made of the Icelandic hot springs, by Dr. *Black* of *Edinburgh*, together with a full detail of the method he pursued. In this inquiry, he likewise was supplied with the water by Mr. *Stanley*.

In order to compare the results of the analysis of the spring-water at Rykum, made by Dr. *Black*, with mine, I reduced the constituent parts, enumerated by him, to the proportion of 100 cubic inches, equal to 29,000 grains of water. Hence, omitting unimportant fractions, they stand in the following proportion:

D d 2

Carbonated

|                                     |             |
|-------------------------------------|-------------|
| <i>Carbonated free soda</i> . . . . | 1,50 grains |
| <i>Silex</i> . . . . .              | 10,80       |
| <i>Muriat of soda</i> . . . .       | 8,40        |
| <i>Dry sulphat. of soda</i> . . .   | 3,70        |
|                                     | <hr/>       |
|                                     | 24,40       |

When the numerous, and partly unavoidable causes are considered, which occasion small differences in the proportion of the constituent parts discovered, these two analyses may be considered, upon the whole, as reciprocally confirming each other. The quantity of *alumine*, which, being very trifling, I have not determined, should, according to Dr. Black's analysis, be estimated at  $\frac{1}{7}$  of a grain in 100 cubic inches of water.

What in particular has attracted the attention of Dr. Black is the *siliceous earth* he discovered, and its solution in water. For this reason he says, that in the course of that inquiry he had detected in *silex* such properties as have never before been suspected in it, or never been accurately described. He here principally alludes to the fact, that *siliceous earth* dissolved by fixed alkalis will not separate from them, even when neutralized by alkalis, as long as a sufficient quantity of water required to that effect is present\*.

Dr. Black asks; "How and by what means is the *siliceous earth* dissolved in water?—Is the hot water, of its own accord, possessed of the power of dissolving this

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\* Without inculpating the ingenious Dr. Black for this little deficiency in his acquaintance with the experiments made by the German Chemists, I cannot avoid remarking, that I have, at an earlier period, known and described that property of *siliceous earth*. See my *Chemische Untersuchung des Elastischen Steins aus Brasilien*, im. 6. B. der Schrift. d. Berl. Gesellschaft Naturforsch. Freunde. 1785.

"earth;



“ earth ; or can this be effected only by the means of the “ intervening alkali ?”—In answering these questions, he does not approve of *Bergmann's* opinion, that the solvent power of water, assisted by heat, is alone sufficient for this effect. He rather thinks, that the alkali is the efficient cause of this solution, and the heat merely a means of promoting it. In his opinion, a chemical combination of the siliceous earth with alkali is always present, when water exerts a dissolving power on the earth, and this idea he supports by the example of the agency of hot aqueous vapours upon glass. The doubt, which might be raised against it, from the disproportion of these two substances to each other in the Icelandic hot springs, he wishes to obviate by stating, that the siliceous earth had originally been united in them with a much larger portion of alkali ; but that, subsequently to the solution of this compound in water, part of the alkali had again been neutralized by acids, or acid vapours, that combined with the fluid. But there is no necessity for this mode of explanation ; as it is manifest by several facts, that siliceous earth alone, if under favourable circumstances, is soluble in water, without the concomitant aid of alkaline salt.

Moreover, this opinion, that the siliceous earth exists in the above mentioned springs in a state of chemical solution by soda, seems likewise to have led Dr. *Black* to presuppose this alkali in those waters in the *caustic* or *pure state*, that is, *free from carbonic acid* ; because it is allowed on all hands, that, in this state only, is it capable of effecting this solution. Yet, not to mention that no proof is given of this hypothesis, there occurs no instance in nature, upon which to establish its probability. The very effervescence, that ensued on saturating with acetic acid the saline residue left by the evaporated water, would prove the contrary ; unless, indeed, it be objected to this argument, that the alkali had attracted the carbonic acid, during the evaporation of the water.

## XLI.

CHEMICAL EXAMINATION  
OF THE  
*SILICEOUS TUFA, (Kieseltuff.)*

*From the Geyser.*

IN the same manner, as mineral waters impregnated with lime deposit the *calcareous* tufa in various forms, do the hot springs in Iceland deposit their *siliceous* ingredient in the form of tufa. It is likewise of this *siliceous* tufa that the wonderful pipe and basin consist, which the *Geyser*, the largest of the springs in Iceland, has formed for itself. *Von Troil* found, in the year 1772, the circular orifice of that pipe, whose depth is unknown, and which the ignorant Icelander considers as the gate of hell, to be 19 feet in diameter. On the upper part, the aperture widens in the form of, a large basin of 60 feet in diameter, and whose exterior border is 9 feet higher than the pipe itself. From this pipe the water spouts out several times in the day, by gushes, at unequal intervals of time, with powerful force, and sometimes to the height of above 100 feet. What a grand sight must it afford, to see a column of boiling water, 19 feet in diameter, rush up to such a height! To form an idea of that column of water, let it be compared with the most celebrated artificial fountains, for example, that on the *Carlsberg* near *Cassel* in *Hessia*, which is only 14 inches in diameter, and hence is more than 16 times smaller than the *Geyser*.

As



As the siliceous tufa produced by this spring is to be met with only in few collections ; and as,—besides the short account given by *Bergmann*, in his treatise *De Productis Volcanicis*,—no other characteristic description of it exists, I here insert that, which *Karsten* has drawn from the specimens in my possession.

*SILICEOUS TUFFA.*

“ Its colour is partly *reddish-white*, and externally speckled with *coccineal-red* ; partly *greyish-white*, with yellowish-grey stripes.

“ It occurs in *massive* lumps, and also *denticulated*, *corroded*, and most finely *botryoidal*.

“ Its exterior surface *perfectly-dull*.

“ But internally partly *dull*, in part highly *glittering*, and then of a *silky lustre* ; here and there a little *resplendent*.

“ Its fracture partly *compact*, and totally *flat conchoidal*, or *uneven* ; partly *fibrous*.

“ It breaks into indeterminate angular, not very sharp fragments.

“ It consists, when *conchoidal*, of *finely grained* insulated pieces ; when of *uneven fracture*, it then is found in separate *thin* and *curved testaceous* pieces ; and its fibrous varieties present no detached pieces.

“ It is also, more or less, *strongly transparent on the edges*.

408 XLI. *Siliceous Tufa from the Geyser.*

“ *Semi-indurated*; may be split in pieces without any great difficulty; is very *brittle*, and of little *weight*.”

*Note.* The *fibrous* variety has always the lustre of silk, and the fibres cross each other in such a manner, that its inside has a *cellular* appearance.

For the following analysis of the *siliceous tufa from Iceland*, I have chosen the *fibrous* variety, whose specific gravity is = 1,807.

One hundred grains of it were finely triturated, and ignited for two hours, in a silver crucible, with four times its weight of mild pot-ash. When the concreted mass had cooled, I poured water upon it, saturated it to excess with muriatic acid, and filtered it after some digestion; upon which the *siliceous earth* remained behind in its usual slimy form.

The acid fluid, being afterwards saturated with mild, or carbonated pot-ash, was rendered turbid by it; and deposited a slight loose precipitate; which, collected, washed, and desiccated, weighed 3 grains; but when re-dissolved afresh in muriatic acid, it still left 1 grain of *silica*.

The solution still contained 2 grains of dissolved matter: namely,  $\frac{1}{2}$  grain of *oxyded iron*, and  $1\frac{1}{2}$  grain of *aluminous earth*. These, likewise, were separated.

Hence the ingredients, found in the above 100 grains of analysed *fibrous siliceous tufa*, from the *Geyser*, consisted of:

|                     |       |
|---------------------|-------|
| <i>Silica</i>       | 98    |
| <i>Alumina</i>      | 1,50  |
| <i>Oxyd of iron</i> | 0,50  |
|                     | <hr/> |
|                     | 100   |



## XLII.

## CHEMICAL EXAMINATION

OF THE

## ELASTIC QUARZ\*,

*(Sand-schiefer, flexible Sand-stone)**From Brasil.*

THE singular elastic flexibility so seldom occurring in the mineral kingdom, in which this fossil, in its form and appearance, resembles novaculite (Turkey-hone), has attracted the attention of Naturalists, but at the same time has led many persons to doubt its existence as a natural substance, and to suspect, that this may probably be a product of art. It comes from Brasil, near *Villa-rica*, the principal town of the province of *Minas Geraës*, which fact was, for a while, kept a secret. There it occurs in not very thick strata, whose *hanging* and *spading sides* are cased over by a grey crust of  $\frac{1}{4}$  inch thick; and from thence it was brought

\* *Schriften der Berliner Gesellschaft Naturforschender Freunde.* 6. B. 1785, pag. 322.—The miners indicate by these expressions the greater or less slope in the strata, though chiefly with reference to *rake-veins*, not fully perpendicular. The hanging side is that towards the day, and is also called *banger*; and the hading side, which likewise goes by the name *ledger*, is the under one next to the bed of the stratum. See *Williams's Natural History of the Mineral Kingdom*, 8vo. Edinb. 1789. vol. I. page 269.—Transl.

to Portugal the first time, in the year 1780, by the *Marquis de Lavradio*, Viceroy at *Rio de Janeiro*. Among the specimens I have seen, that of the Imperial Cabinet at Vienna, so remarkable for its precious fossils, is by far the greatest; it being 26 Vienna inches long, 16 inches broad, and 1 inch thick. It is, however, probable that this stone, together with its remarkable physical property mentioned before, was already known in the sixteenth century; and that it is the same with that described by *Gassendi* in *Vita Peireskii*\* in the character of a *flexible wetstone* (novaculite); as suggested by the authors of the *Göttingische Gelehrte Anzeigen*, when this stone has again been brought into notice †.

## A.

On inspecting with a microscope the homogeneous or integrant parts of which this elastic stone is aggregated, and which may be easily separated by compreffure or levigation, I found them all alike: that is, they were all flat, longish plates or scales, perfectly clear and pellucid. All their difference consisted in the variety of their outlines; some truncated more sharply; others more obtusely; others longer, but very thin; while others were broader and shorter; but most of them I perceived on one or both sides notably sinuated. I am inclined to think, that the elasticity of this fossil originates solely from the form of its aggregation. For, as may be distinctly seen at the first glance in the entire stone, all those longish lamellæ are interwoven

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\* Libr. IV. ad annum 1630. pag. 254. Edit. 1706.

† Of the year 1784. Number 211.



in *one single* direction, and implicated in such a manner, that each junction resembles a vertebra, or hinge. With this idea also corresponds the particular kind of the flexibility of the stone, which is not tough or coriaceous. For, if the stone be held upright and shaken, it vibrates with some poise to and fro; but as soon as its agitation is discontinued, its parts conjoin again firmly by a force like a spring.

B.

I now proceed to its chemical analysis.

a) As, on triturating, I found the particles of the stone extremely hard, which was indeed previously ascertained by its faculty of cutting glass with ease, and of striking fire with steel, I endeavoured to facilitate its decomposition by previous mechanical comminution.

To effect this, I subjected *one hundred* grains to red-heat, and quenched them in cold water; but I observed, that by this neither their weight nor their hardness had decreased. They were then reduced to an impalpable powder in an agate mortar, mixed with four parts of dried carbonated soda, and ignited under the muffle in a porcelain-faucer, during six hours, in a moderate degree of heat; by which the mixture only conglutinated, without actual fusion. The ignited mass was pulverized with water, super-saturated with muriatic acid, digested and filtered. A quantity of very loose *siliceous earth*, to the weight of  $96\frac{1}{2}$  grains, remained on the filter.

b) The separated muriatic fluid was treated with Prussian alkali; and the blue precipitate, thence arising, ignited.

I

It

412 XLII. *Examination of Elastic Quarz.*

It weighed one grain; of which, however, only  $\frac{1}{2}$  grain can be reckoned as *oxyd of iron*, entering into the 100 grains of the decomposed fossil.

c) At last, by saturating the solution with carbonated potash, a tender earth was thrown down; which, after washing, drying, and ignition, weighed  $2\frac{1}{2}$  grains; and, examined by means of sulphuric acid, was found to be *aluminous earth*.

Consequently, *hundred parts of elastic quarz from Brasil* have yielded:

|                               |       |
|-------------------------------|-------|
| <i>Silex</i> . . . . .        | 96,50 |
| <i>Alumine</i> . . . . .      | 2,50  |
| <i>Oxyd of iron</i> . . . . . | 0,50  |
|                               | <hr/> |
|                               | 99,50 |

There are sometimes very small blackish grains, like points, mingled with this stone. As these probably are garnets, or crystals of horn-blende, it seems that the portion of iron and alumine discovered in the fossil chiefly proceeds from them.



## XLIII.

## CHEMICAL EXAMINATION

OF THE

*GLASS-STONE (Hyalite),**From Dauphiny\*.*

AS the term *Schörl* was formerly used in too vague a sense; to remedy this uncertainty, it has been found necessary to confine its mineralogical signification within narrower limits. On this consideration, the fossil here treated of, which *Romé de l'Isle* has first introduced into public notice, by the name, *Schörl transparent, lenticulaire*, but which has since become more known by that of *Violet-Schörl*, could no longer be ranked under that head. *Werner*, therefore, has classed it as a distinct species, and given it the name, *Thumerstone*. But it also has got other names, such as, *Glasf-stone*, or *Haylite*, *Pseudo-schörl*, *Glasf-schörl*, *Oisannite*.

It was, for the first time, discovered in *Dauphiny*, chiefly at *Bourg d'Oisans* near *Allemont*; partly upon a blackish-grey horn-blende-stone, partly in the clefts of a greenish-grey gneiss, already somewhat softened by decay, where it is accompanied by quartz, amianth, and crystallized actinolite. Most of its crystals are upright, and their leading figure is very compressed rhomboidal parallelopipedons or

\* See *Magazin für Die Naturkunde Helvetiens*. I. B. 1787 pag. 180.

flat rhomboidal tables, sharply truncated, and of a fine striated surface. The colour of the purer translucent crystals is a faint amethystine-red, which in the less bright crystals changes to the white-grey.†

Glass-stone, or *hyalite*, is also found in the Pyrenees at *Barèges*, and other places; but not in such clear and large crystals as that of Dauphiny.

The third place where this fossil occurs is the mine *Niklas*, at *Thum*, near *Ehrenfriedersdorf* in Saxony; where it is rarely met with in a crystallized state, but mostly in separate, massive, testaceous pieces.

Besides these, I have likewise found it in a specimen of native silver, from *Kongsberg*, preserved in the instructive collection of Mr. *Siegfried* at Berlin.

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a) Glass-stone, treated upon charcoal before the blow-pipe, foams much as soon as it becomes red-hot, and readily melts into a black, shining, opaque bead. This phenomenon, along with the great difference of its external characters, affords a sufficient ground to separate the *hyalite* from *shörls*, with which it has been confounded. The true *shörls*, indeed, likewise fuse upon charcoal; however, *first*, their fusion is not accompanied by a brisk effervescence, but rather by a languid swelling; *secondly*, a much stronger and more lasting heat is required, to make pure *shörls* run into a globule equally fused in all its parts; and, *thirdly*,

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† Fuller descriptions of its external characters are found in the later mineralogical elementary books, among which descriptions, that given by *Esfner* is the most complete. See his *Mineralogy*. II. B. I. Abth. S. 258.



most species of shörls, if not all, lose their colour by the fire; whereas the clearest and least coloured fragments of that fossil yield a completely black vitreous bead. In this respect, hyalite agrees more with horn-blende\*.

b) To discover the constituent parts of hyalite, I chose that from Dauphiny, first mentioned. *One hundred and sixty* grains of the purest crystals, broken off from several *druses* (regular crystalline groupes), were ignited for one hour in a porcelain-pot, at a degree of heat not intense enough to fuse them. Their weight, colour, figure, and hardness, continued unimpaired. Only three grains were lost during trituration.

c) These 157 grains of the pulverized stone, mixed with three times their weight of exsiccated soda, were exposed for three hours to a gentle red-heat, in a porcelain pot. After cooling, they were found conglutinated into a blueish-grey, compact, hard, finely porous mass, readily separable from the sides of the vessel. When finely ground, covered with water, and super-saturated with muriatic acid, the mixture acquired a gelatinous consistence, and a dirty brown colour. On diluting it with more water, and digesting it, oxygenated muriatic acid gas was extricated, and the brown colour disappeared; the fluid, superincumbent on the undissolved, white, slimy earth, being clear and of a gold-yellow. This earth, after decanting the liquor, was digested anew with muriatic acid; then separated by filtration, washed, and strongly ignited. It weighed 79 grains, and was *siliceous earth*.

d) To obtain first of all the metallic part of the solution, I gradually dropped Prussian alkali into it, as long as any

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\* On the habitudes of this fossil in porcelain-fire, see Essay I. No. 26.



precipitation would ensue. The deep-blue precipitate, thus procured, weighed  $61\frac{1}{2}$  grains, upon washing and drying; but, when strongly ignited, there remained only 28 grains, which consisted of *black oxyd of iron*, obeying the magnet. From these must be subtracted the portion of iron retained by the salt employed; and hence, (from the result of another essay, made on purpose with a portion of Prussian alkali of the same preparation) only 15 grains of that metal are left to be put in the account as a constituent part of the fossil.

e) The amethystine red colour of the rough crystals, and the blueish colour of the mass fused with soda, but still more the vapours of oxygenated muriatic acid emitted during the solution, shewed that *manganese*, as well as iron, was present in this instance. For this reason, I ignited those 28 grains of oxyded iron (*d*), adding 10 drachms of nitre; and when this last had been for a while in red fusion, I poured it off from the iron that lay at the bottom of the crucible upon a marble slab. When fixed again, the nitre appeared of an emerald-green. Thrown into water, it soon dissolved, tinging the liquid of an amethystine-red; and, when this colour had vanished, *manganese* fell down in light-brown, loose flakes, weighing  $1\frac{1}{4}$  grain. But, on being farther tried, it was found to be still mixed with iron.

f) I next began to examine the dissolved earths.—By the perfect and ready fusion of hyalite alone, and without addition, I was induced to suspect in it a considerable proportion of calcareous earth; but neither oxalic acid alone, nor oxalat of pot-ash, produced any turbidness or precipitate. However, as the sequel has shewn, lime was, nevertheless, present. This fact may serve as a caution, that even the very best re-agents ought not to be always trusted to with unlimited confidence.

Carbonated



Carbonated pot-ash was now employed to precipitate the earth contained in the solution. It fell down, white, and of a loose form; and weighed 91 grains after washing and deficcation in a low heat. The fluid filtered off, together with the washings, were entirely evaporated, and the remaining dry saline mass re-dissolved with a little water. By this management  $1\frac{1}{2}$  grain of a granular earth was still left, which I added to the preceding 91.

g) Upon these  $92\frac{1}{2}$  grains of earth I affused one ounce and a half of distilled vinegar, concentrated by freezing, leaving the whole standing for 12 hours. A feeble, but lasting effervescence took place. The acetic solution being decanted, another fresh ounce of acetic acid was affused upon the sediment; and, after 12 hours, it was exposed to a moderate temperature. When, after 48 hours, the subtle earth, which gave the solution an opaline appearance, had subsided, I collected it upon the filter; washed, dried, and ignited it. It weighed then  $41\frac{1}{2}$  grains. At this time the acetic solution yielded a white precipitate, by uncombined as well as by neutralized oxalic acid. But, as from this alone no certain conclusion could be made as to the presence of lime, I added to that fluid successive portions of sulphuric acid, till the white granular precipitate ceased to fall down. The mixture, a little evaporated and filtered, left sulphat of lime behind, which, after ignition, weighed 38 grains.

h) The liquor, filtered off from this last, was combined with caustic ammoniac. *Aluminous earth* fell down, weighing  $2\frac{1}{2}$  grains when ignited. The remainder of the solution afforded still some selenite, on evaporation to dryness; which, ignited, left two grains, and was added to the preceding 38 grains (g).



i) In order to decompose the selenite, I boiled it during a quarter of an hour with a solution of carbonated pot-ash, in such a proportion as made the alkali predominate. The earth left behind weighed  $26\frac{1}{2}$  grains, after washing and torrefaction; and proved, upon trial, to be a highly pure carbonat of lime. Therefore, since nine parts of crude calcareous earth afford by ignition five parts of burnt or quick-lime, the above-mentioned  $26\frac{1}{2}$  grains are equal to  $14\frac{1}{2}$  grains of *calcareous earth*, freed from water and carbonic acid.

k) Those  $41\frac{1}{2}$  grains of earth (g), together with the  $2\frac{1}{2}$  grains (b), which I took for *alumine*, were combined with three drachms of concentrated sulphuric acid, and then diluted with some water. The mixture exhibited a pleasing rose-colour; but which, on inspissating the fluid almost to dryness, passed into a light blue: shewing thus the presence of a small trace of *manganese*. On being re-dissolved in water, it yet deposited some *siliceous earth*, weighing  $3\frac{3}{4}$  grains, after ignition. By subtracting these from the foregoing 44 grains, that were held in solution by the sulphuric acid here employed, the quantity of *aluminous earth* found in the fossil is reduced to  $40\frac{1}{4}$  grains.

l) To be assured that this ingredient is pure alumine, unaccompanied by magnesia, I heated the solution to the degree of boiling, and gradually saturated it with elutriated chalk, until it effervesced no more, and no acid could be observed to predominate. After gentle boiling for half an hour, I filtered the fluid, reduced its quantity by evaporation, and separated the selenite which yet appeared. However, no sign of sulphated magnesia could be perceived in the solution, either by the taste or by re-agents.

Thus



# *Hyalite from Dauphiny.* 419

Thus the decomposed 157 grains of *hyalite*, from Dauphiny, have yielded:

|                                       |   |         |
|---------------------------------------|---|---------|
| <i>Silex</i> . . . . . c) . . . 79    | } | . 82,75 |
| — . . . . . k) . . . 3 $\frac{3}{4}$  |   |         |
| <i>Alumine</i> . . . . . k) . . . . . |   | . 40,25 |
| <i>Lime</i> . . . . . i) . . . . .    |   | . 14,75 |
| <i>Oxyd of iron</i> , including       |   |         |
| that of <i>manganese</i> d) . . . . . |   | . 15    |
|                                       |   | <hr/>   |
|                                       |   | 152,75  |
| Lofs . . . . .                        |   | 4,25    |
|                                       |   | <hr/>   |
|                                       |   | 157     |

Wherefore, an hundred parts contain:

|                                             |      |
|---------------------------------------------|------|
| <i>Silex</i> . . . . .                      | 52,7 |
| <i>Alumine</i> . . . . .                    | 25,6 |
| <i>Lime</i> . . . . .                       | 9,4  |
| <i>Oxyd of iron and manganese</i> . . . . . | 9,6  |
| <hr/>                                       |      |
| 97,3                                        |      |

## XLIV.

## CHEMICAL EXAMINATION

OF

## CHRY SOP RASE,

*And its concomitant Green Earth\*.*

CHRY SOP RASE is a natural product, hitherto exclusively of Silesia, chiefly found near the village *Kosmütz*, in the Principality of *Münsterberg*; where it occurs in the clefts and disjunctions of a soft serpentine rock, together with quartz, hornstone, chalcedony, opal, asbest, talc, (*magnesia*) and various other species of earths †.

Authors are not agreed in stating the constituent parts of chrysoprase. Their opinions chiefly differ with respect to the principle that produces the green colour of this stone: some ascribing it to iron, others to cobalt, and some again to copper.

## FIRST SECTION.

*Analysis of Chrysoprase.*

a) Some selected, pure pieces of chrysoprase were heated to redness, and quenched in water. Their colour was

\* See *Beob. u. Entd. a. d. Naturkunde*, 2 B. 2 St. Berlin, 1788. p. 17.

† A more circumstantial account of the natural history and bed of chrysoprase, and the stones that accompany it, is given in *Lehmann's Physisch-chemischen Schriften*—and *Gerhard's Beyträgen zur Chemie, and Geschichte des Mineralreichs*; as also in his *Grundriss des Mineralsystems*.

hereby



XLIV. *Examination of Chrysoprase, &c.* 421

hereby changed to a blueish-grey; and, by a second torrefaction and quenching, into a blueish-white. The stone lost  $1\frac{1}{2}$  per cent. by the ignition, and became so soft, that it admitted of being easily ground to a very subtle powder.

Three hundred grains of this powder, mixed with twice their weight of dry carbonated soda, were subjected to a low red-heat for some hours, in a vessel made of porcelain-clay. The mass was then powdered while yet warm, and digested with water. The solution acquired a dirty brownish colour, and left, upon filtration, a grey-yellow residue of 44 grains whenedulcorated and dried. It passed colourless through the filter, and by saturation with muriatic acid, it yielded a copious precipitate; which, collected, washed, dried, and ignited, consisted of  $268\frac{1}{4}$  grains of *siliceous earth*.

b) Upon the 44 grains of residue, that were separated on dissolving the ignited mass in water (a), introduced into a retort, I poured *eight* times their weight of nitro-muriatic acid, and digested them together. This done, I abstracted the greatest part of the acid, and what had distilled over I returned upon the contents of the retort; digested it once more, and then filtered the whole. There remained on the paper a white, loose *siliceous earth*, weighing  $20\frac{1}{4}$  grains upon ignition.

c) To the filtered solution I added caustic ammoniac in excess. Its colour, which before was of a dilute green, turned blueish; and a little brownish matter fell down in the form of slime. Upon this precipitate nitric acid was affused in a small retort, and again distilled off from it. This affusion and abstraction were repeated twice more; and, at last, the retort was strongly heated to redness upon charcoal. The residue I then dissolved in weakened nitric acid. A brown *oxyd of iron* remained, amounting to  $\frac{1}{4}$



grain, which, dissolved in muriatic acid, afforded, with Prussian alkali, a deep blue; and, with tincture of galls, an ink-black precipitate. Whence this portion of iron, as it is so small, can have no share in producing the green colour of *chrysoprase*.

From the nitric solution, cleared from iron, carbonated ammoniac precipitated  $\frac{1}{2}$  grain of loose *aluminous earth*, weighed in the dry state; but for which, in the ignited state, only  $\frac{1}{4}$  grain can be reckoned.

No trace appeared of *magnesian earth*.

d) The solution, super-saturated with caustic ammoniac (c), was tried for lime; and with this view combined with carbonated soda. The precipitate produced was carbonat of lime. Upon desiccation, it weighed  $4\frac{1}{2}$  grains, which denote  $2\frac{1}{2}$  grains of *calcareous earth*, in the ignited state.

e) The fluid, from which this lime had been separated, still preserved its blueish colour (c), and yielded no precipitate, either with acids or with alkalis. For this reason, it was distilled to dryness. There remained in the retort a yellowish saline mass, which again made a green solution with water. When this solution had been combined with mild pot-ash, it deposited only a slight portion of a white-greenish earth; the remainder would not precipitate, notwithstanding all my endeavours: therefore, I dropped into the mixture as much nitric acid as was necessary to re-dissolve the precipitate, and treated it with prussiat of pot-ash, until the whole was separated. The collected, washed, and dried precipitate had a sea-green colour, and weighed 17 grains.

f) In this precipitate, therefore, that constituent part of *chrysoprase* was contained, on which its green colour depends.



pend. — What then is this constituent part? Certainly not iron; for this, by its nature, will never dissolve in caustic ammoniac, nor ever produce with it a blue colour. Besides, it would have been precipitated of a deep blue, by the Prussian alkali, with which it was tried (c); and, lastly, the oxyd of iron, of which there exists only a very slight portion in the chrysoprase, had already before been separated (e). Neither can it be said, that copper forms any part of that precipitate. This metal does indeed dissolve of a blue colour, in ammoniac, as does the above-mentioned precipitate; but as this property does not exclusively belong to copper alone, no decisive conclusion can be deduced merely from this circumstance. Moreover, the bright aqua-marine colour of this precipitate, produced by means of prussiated pot-ash, has absolutely nothing in common with the red-brown colour, with which copper always presents itself, when thrown down from any solvent by that precipitant.

But the most convincing proof of the total absence of copper in this instance was afforded by the following experiment: I exposed the 17 grains of the greenish precipitate (e) to red-heat, in a crucible, and subjected the black-brown residue, which weighed seven grains, to vigorous digestion in nitric acid. By this treatment, a slight quantity of iron, originating from the Prussian alkali employed for the precipitation, was deposited; and all the remainder afforded a green solution with nitric acid. This I distributed into two phials; putting into the one a piece of polished iron, and into the other a stick of zinc. But in neither of them, both in the cold or heated, could the least indication of copper be observed.

g) After I was thus fully certain that no copper was present, I could not account for this constituent part of chrysoprase, otherwise than by taking it for oxyded nickel.



This conclusion was corroborated by all the phenomena above-mentioned, which wholly resembled those of other experiments which I made, by way of trial, with an oxyd, prepared from the utmost pure reguline nickel.

Being accustomed to repeat those experiments, which lead to new discoveries, in order to secure myself, by the agreement of the results, against accidental mistakes, I subjected another quantity of chrysoprase to analysis.

The blue solution of oxyd of nickel in ammoniac, which I then obtained, I distilled to dryness from a retort; after which, I roasted the residue with wax, in a gentle heat, and tried to reduce it to the reguline state upon charcoal, by means of borax and fusible phosphoric salt. The reduction succeeded with either flux; but it required to be strongly assisted by the blow-pipe. While reducing with borax, the metal would not easily run into a button; but, with the phosphoric salt, it proved somewhat more fusible, and yielded a white-grey bead, that exhibited a shining polyhedral surface, and a finely grained fracture.

These metallic buttons were too few to admit of a farther examination. For this reason, I endeavoured to procure more of them, which I effected by decomposing the green earth of chrysoprase, described in the following section; and the third section will shew, that those seven grains of the precipitate obtained by Prussian alkali, and ignited (*f*), denote  $2\frac{1}{2}$  grains of metallic nickel; or three grains of pure oxyd of nickel, when heated to redness.

Whence the constituent parts, produced from the 300 grains of *chrysoprase* decomposed, are:



|                          |    |                   |               |
|--------------------------|----|-------------------|---------------|
| Silex . . . . .          | a) | 268 $\frac{1}{4}$ | } 288,50 grs. |
| — . . . . .              | b) | 20 $\frac{1}{4}$  |               |
| Alumine . . . . .        | c) |                   | 0,25          |
| Lime . . . . .           | d) |                   | 2,50          |
| Oxyd of iron . . . . .   | e) |                   | 0,25          |
| Oxyd of nickel . . . . . | g) |                   | 3             |

---

294,50

Loss, which the chrysoprase suffers by  
ignition, and chiefly consists of par-  
ticles of water . . . . . a)

5,50

---

300

With this proportion of the constituent parts of chrysoprase, the results of several of my experiments agree pretty well. Yet I readily admit, that, on repeating such experiments, some small differences may take place, especially in the portions of iron and nickel, since the green colour of this fossil so often varies. In like manner, I have sometimes discovered more sensible indications of magnesian earth, though never amounting to more than  $\frac{1}{5}$  per cent.

## SECOND SECTION.

### *Analysis of the Green Earth of Chrysoprase.*

a) Among the varieties of the glittering, fattish, green earth, that sometimes accompanies chrysoprase, I selected that for the present enquiry, which by its uniform apple-green colour is distinguished from the others, as the most pure and least contaminated with heterogeneous matters. Upon *three hundred* grains of this, put in a retort, I poured four times their weight of an *aqua regia*, composed of three parts of muriatic, and one of nitric acid, and at first digested

gested them for a while. The action of the acid upon the earth was attended with an extrication of yellowish vapours. That portion of the acid which passed over was poured back into the retort, with the addition of one part of fresh nitric acid; and, after a second digestion, distilled off to moderate dryness. The remaining mass, whose green colour was now changed into a yellow, was again digested with the acid that had been abstracted, and next separated by filtering from the indissoluble residue.

b) This residue, which resisted the attack of the digesting acid, consisted of a very tender, loose, dazzling-white, and glittering *siliceous earth*, that weighed 105 grains after deffication in a red-heat. I mingled and ignited it with 210 grains of carbonated pot-ash; upon which I tritured the mass with water, super-saturated it with nitric acid, digested and filtered it. In the fluid that passed through the paper nothing could be found, except *one grain* of filex.

c) The solution, separated from the filex (a), had a green colour. It was combined with carbonat of pot-ash, and the precipitate produced wasedulcorated and dried in the air. This precipitate had a pale green colour, like the crude earth, and weighed 280 grains. By way of previous examination, I dissolved *one fifth part* of it in muriatic acid, and tried the solution, which again exhibited its original green colour, in the following manner:

*a)* *Ammoniac* threw down a white green precipitate, which, on adding more ammoniac, in part re-dissolved, and produced a blue tincture.

*β)* By means of *prussiated pot-ash*, a copious sea-green precipitate, inclining to blue, fell down.

*γ)* *Tincture*



γ) *Tincture of nut-galls* produced a faint ink-colour.

δ) With *alkaline sulphuret* there arose a blackish precipitate.

ε) In the remainder of that fifth part of the muriatic solution I immersed a *polished iron*, which became tarnished, of a grey colour; but no sign of copper, either in a cold or a warm temperature, appeared.

d) The other four-fifth parts of the green precipitate (c), which now contained one half ounce of rough earth of chrysoprase, cleared from filix, were dissolved in nitric acid, and treated with an over-proportion of carbonated ammoniac, shaking it several times. The supernatant blue solution was decanted on the next day from the residue; and to this last fresh portions of ammoniac were repeatedly added, till it ceased to afford a blue tincture, that could be observed.

e) The residue, left after the extraction by ammoniac, was a loose white-grey earth, weighing 85 grains when dried in the air. It was dissolved by digestion in nitromuriatic acid, and treated with caustic ammoniac, until nothing more fell down. The light-brown precipitate then obtained was heated to redness; after which it weighed 26 grains. Nitric acid was next affused upon it in a retort, and again abstracted by distillation; and this abstraction and digestion were repeated twice more. I then urged the fire of the coals so as to redden the retort, powdered the calcined residue, dissolved it in dilute nitric acid, and threw it upon the filter. There remained a red *oxyd of iron*, which, dried and deflagrated with wax, was attracted by the magnet, and weighed eleven grains.

f) The

428 XLIV. *Examination of Chrysoprase,*

f) The 15 grains which yet remained in the solution after the separation of these 11 grains of iron (e), were precipitated by mild soda, desiccated in the air, and extracted in the cold by distilled vinegar. This attacked it with effervescence; but, when again filtered off, and treated with carbonated soda, it deposited, without any effervescence, a loose earth, which after ignition weighed three grains; and, being tried with sulphuric acid, proved to be *magnesia*. The remaining earth, now reduced to 12 grains, when calculated the ignited state, was *alumina*.

g) There still remained that fluid (e), from which the iron, and the magnesian and aluminous earths were precipitated by caustic ammoniac. It was warmed, and combined with carbonat of soda, which precipitated  $1\frac{1}{2}$  grain of crude *calcareous earth*, for which, to avoid small fractional parts, I put one grain of burnt *lime* in the account.

h) I now return to the blue extraction, prepared with carbonated ammoniac (d). I distilled it, together with the water employed for lixiviating the residue, from a retort, almost to dryness. The residue I softened with water, and found, that, upon filtration, it left seven grains of a pulverulent isabella-coloured earth; which, by ignition, lost one half of its weight, yet continued unchanged in colour.—When previously dissolved in nitric acid, it was thrown down of a white-yellow by alkalis, of a pale olive by pruffed pot-ash, and of a light-brown by arsenical alkaline sulphuret; but by the tincture of galls it would not at all precipitate. On this account I considered it as an impure *oxyd of nickel*.

i) As no ammoniac any longer predominated in the fluid which had been filtered off from the isabella-coloured earth (h), it had again a bright grass-green colour. I now  
endeavoured



endeavoured to separate the substance which it held in solution, by adding alkaline salts.—Yet I could not completely succeed; and, notwithstanding that I watched the most exact point of saturation, this middle (or earthy) saline liquor still retained part of that substance in a dissolved state. The greatest portion of the precipitate I first obtained by means of mild ammoniac; and when this had been separated, mild pot-ash threw down another portion. The precipitate, collected, washed, and dried in the air, had a pale, whitish-green colour, and weighed 50 grains.

k) Thirty grains of this precipitate were ignited for  $\frac{1}{2}$  an hour; whereby its whitish green was altered to a grey-green: and it lost half of its weight. Those 50 grains, therefore, must be estimated at 25 grains of ignited *oxyd of nickel*. In this instance I did not perceive that sort of efflorescence which usually takes place when oxyds of nickel, procured from ores of that metal, are exposed to fire; perhaps, because no portion of arsenic, by the escape of which those delicate ramifications are probably produced, was here present.

l) Since neither acids nor alkalis would precipitate any thing from the remainder of the fluid above mentioned (i), it now only remained to apply prussiat of pot-ash. This still precipitated a considerable quantity of a pale sea-green earth; which, upon washing and ignition, became granular, assumed a brown colour, and weighed 21 grains. This quantity, calculated after the manner to be explained in the third section, indicates 9 grains of ignited, pure *oxyd of nickel*.

Therefore, the constituent parts contained in half an ounce of that variety of the green-earth of *chrysoprase*, which had

430 XLIV. Examination of Chrysoprase,

had been employed for this investigation, are the following:

|                                                                                   |    |                |           |
|-----------------------------------------------------------------------------------|----|----------------|-----------|
| <i>Silex</i> (since 105 grains were<br>obtained from 300<br>grains of that earth) |    | b)             | 84 grains |
| <i>Alumine</i> . . . . .                                                          | f) | 12             |           |
| <i>Magnesia</i> . . . . .                                                         | f) | 3              |           |
| <i>Lime</i> . . . . .                                                             | g) | 1              |           |
| <i>Oxyd of iron</i> . . . . .                                                     | e) | 11             |           |
| <i>Oxyd of nickel</i> . . . . .                                                   | b) | $3\frac{1}{2}$ |           |
| _____ . . . . .                                                                   | k) | 25             |           |
| _____ . . . . .                                                                   | l) | 9              |           |
|                                                                                   |    |                | 37,50     |
|                                                                                   |    |                | 148,50    |

|                                                                                                     |  |   |       |
|-----------------------------------------------------------------------------------------------------|--|---|-------|
| Loss, very nearly approaching that<br>which the rough earth of chryso-<br>prase suffers by red-heat |  | . | 91,50 |
|                                                                                                     |  |   | 240   |

### THIRD SECTION.

#### Closer Examination of the Portion of Nickel contained in Chrysoprase, and its concomitant Green-earth.

In order to examine more accurately the whitish-green metallic oxyd that enters into chrysoprase, as well as its concomitant green-earth, I procured another quantity of it, by repeated decompositions of those two substances, performed in the manner before described. This I subjected to the following experiments.

a) Treated with *ammoniac*, it soon dissolved, and yielded a pure blue tincture, though less saturated than that which is af-



afforded by the solution of copper in ammoniac, made with the same proportion of these respective ingredients. If nitric acid be affused in a quantity a little beyond what is necessary to saturate the ammoniac, the solution appears of a light grass green.

b) It entirely dissolved, and with effervescence, in *sulphuric acid*. It likewise gave with this a green solution; from which

a) *Carbonated pot-ash* precipitated that oxyd of a whitish-green.

β) *Prussian alkali* of the same, but somewhat darker colour.

γ) *Tincture of galls* produced no change nor turbidness in the solution.

δ) *Arseniated alkaline sulphuret* threw down a great quantity of a black-brown precipitate; but of which

ε) Neither on *polished iron*, nor on *zinc*, any thing of a metallic nature would deposit; the solution producing only some weak, grey spots on these metals.

ζ) By exposure to open air, this solution shot into clear, emerald-green, rhomboidal crystals of *sulphated nickel*, which, by roasting, crumbled into a white-greenish powder.

η) The green oxyd of nickel, tried upon charcoal, with a blow pipe, shewed the following appearances:—

a) Ignited by itself, it became *violet*; but shewed no disposition to fuse.

I

β) With

β) With *borax*, assisted by a continued stream of air from the blow-pipe, it fused, and was partially reduced to a white-grey metallic mass; but which would not run into one single button.

γ) *Phosphated alkali* likewise reduced it to the reguline state, at the same time that it more readily united into one bead. The glass globule exhibited, during the action of heat, a garnet-red, but, after refrigeration, a hyacinthine colour.

d) I now attempted its reduction in the *crucible*. With this design, I introduced the 15 grains of metallic oxyd, remaining after ignition from those 30 grains mentioned (2 Sect. k), into a crucible, previously mixed with the same quantity of resin, and three times that of calcined borax, and covered the whole with common salt. The vessel was then conveyed to the melting-furnace, and the fire managed in about the same manner as on assaying copper. After cooling, the inside of the crucible was found lined with a thin glazing, on some places of the upper part, of a green, but on the lower one, of a bright hyacinthine colour. The mass itself fused well; and, on breaking the vessel, there was found, under the colourless saline cover, a transparent light-brown glass, and, between this, a metallic button. This, however, being refractory, had not run into a compact mass, but was only conglutinated, consisting of separate, small, loosely-coherent globules.

This metal had a perfect metallic lustre, and a grey colour, verging to the red. When freed by elutriation from the adhering scoria, it weighed  $9\frac{1}{2}$  grains. But as here and there some minute grains were sticking to the fragments of the crucible, not easily separable, I may properly



perly estimate them at  $\frac{1}{4}$  grain; wherefore the weight of the metallic nickel is determined at 10 grains.

a) The magnet has attracted these metallic grains with such rapidity, that, on its approach, the whole quantity adhered to it in an instant; and not one single globule remained behind.

β) One grain of them by weight afforded, with sulphuric acid, assisted by heat, a grass-green solution; from which

γ) Ammoniac again precipitated the metallic part, of a bright whitish-green; but, on being affused in greater quantity, it soon re-dissolved it clearly, and of a sky-blue colour.

δ) Five grains of this reduced nickel, dissolved in nitric acid, and thrown down by Prussian alkali, thenedulcorated and dried, gave a sea-green precipitate; which, exposed to red-heat, left 15 grains of a granular residue, wholly attractible by the magnet.

ε) Those metallic grains urged by the flame upon charcoal, before the blow-pipe, exhibited no disposition to melt, or fuse, but turned to a greenish oxyd.

ζ) When fused with borax, they likewise would not readily enter into fusion. The glass of borax turned ash-grey and opaque; and the metal remained in it in a divided state.

η) But with fusible phosphoric salt they melted pretty soon into one single bead, of a polyhedral surface. The glass globule, which, during the action of heat,

was of a deep garnet-red, became transparent after cooling, and assumed a fine hyacinth colour.

e) Notwithstanding that all these facts, taken together, sufficiently demonstrate that the constituent part of chrysoprase, from which its peculiar green colour arises, is a *true oxyd of nickel*; yet I have, for the sake of superabundant evidence, made other experiments with an oxyd of nickel, which I prepared by the following method.

A portion of *ore of nickel*, from the pit *König David*, on the *Sauberg*, at *Annaberg*, was coarsely pounded, the purest pieces selected, converted into a gross powder, and roasted in shallow pots, as long as any arsenical vapour exhaled. The powdered ore acquired, by this, a dirty green colour, and vegetated, in part, into ramified figures. This oxyd of nickel I reduced with black flux, and obtained a yellowish-white, brittle, metallic button, of easy fusion. This, being once more calcined, was digested in a retort, with an equal quantity of strong sulphuric acid; after which the acid was again distilled over to dryness, and the residue re-dissolved in water, and filtered. At the beginning, the solution deposited small crystals of arsenic; and when these had been removed, the sulphated nickel shot into beautiful, deep-green, rhomboidal crystals. This vitriol of nickel I again dissolved in water, and precipitated it by means of carbonated pot-ash. Upon the oxyd of nickel thus obtained, when washed, dried, and pulverized, ammoniac was affused. This last soon extracted a fine blue tincture, which, filtered off from the residue, was saturated with nitric acid; and, by means of mild pot-ash, all the whitish-green earth which it would yield was precipitated from it.

With this oxyd of nickel, extracted in this way from its ore, I have instituted various experiments, for the sake of  
trial;



trial; which, to avoid prolixity, I shall not particularly enumerate. I will, therefore, only state, that this oxyd, as to the essential phenomena, has perfectly agreed with that extracted from chrysoprase.

f) Those who desire information respecting the habits of nickel in general, I refer to the valuable treatise of *Bergmann* \* on that metal; where he relates his experiments, made with unwearied patience, for the purpose of extracting the regulus of nickel, in a state of purity, from its ores, in which it is constantly accompanied by foreign metallic substances. The difficulties which take place in those processes, I have found confirmed by my own experiments: but I think the best method of obtaining the reguline part of nickel is that described above; namely, by means of ammoniac: yet the product becomes somewhat expensive.

In the chrysoprase, on the contrary, the oxyd of nickel is not mixed with other metallic matters, a very slight portion of iron excepted; and since the process which I have there given likewise serves to separate this inconsiderable ferruginous ingredient, we may safely consider the *metallic nickel*, produced from chrysoprase, or its accompanying green earth, to exist in the state of the *utmost possible purity*.

g) To this assertion, however, it may, perhaps, be objected, that the nickel obtained in that way still obeys the magnet, and, therefore, yet contains some iron. But has it as yet been unquestionably proved, that iron alone is subjected to the law of magnetic attraction?—Have the arguments which various philosophers have brought forward

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\* *Torb. Bergmann Opusc. Phys. et Chim. vol. II. page 231.*  
*De Niccolò.*

against this supposition, been completely refuted?—When the chemist no longer finds any trace of iron in pure cobalt, or in pure nickel, and, nevertheless, observes the magnet to act upon it—can his doubt, whether the attractive force of the magnet be confined only to iron, as has been hitherto believed, be fairly rejected without any farther investigation?

b) I must yet mention some *experiments relative to vitrification*, for which I have used the rough chrysoprase, as well as the oxyd of nickel extracted from it, in combination with various other vitrifying media.

α) *Rough chrysoprase*, finely powdered and  
elutriated, . . . . . 1 part,  
*Carbonated pot-ash*, . . . . . 2 parts,

mixed and fused in a crucible, afforded a violet-blue glass, which deliquesced in the air to a brownish fluid.

β) *Rough chrysoprase* . . . . . 5 parts,  
*Carbonated pot-ash* . . . . . 4 parts,

gave, after a fusion continued for two hours, a beautiful hard glass, of a violet-blue.

γ) *Rough chrysoprase* . . . . . } equal parts  
*Dry carbonated soda* . . . . . } of each

yielded a tourmaline-brown glass, translucent only in thin splinters. Its surface had some delicate veins of reticular delineations; produced by extremely small grains of reduced nickel, lying close to each other in a linear range.

This reduction, which takes place without the addition of any combustible matter, is remarkable. *Lehmann* has before  
I men-



mentioned a bead of reduced nickel, obtained from chrysoprase by reducing fluxes; but he mistook its nature, erroneously considering it as iron.

- d) *Rough chrysoprase*, and  
*Calcined borax*, in equal quantities,

gave a brown transparent glass, resembling rock-crystal of that colour. (*Rauch-topas*).

- e) Prepared *siliceous earth* . . . 80 grains,  
*Carbonated pot-ash* . . . 60  
*Oxyd of nickel, from chrysoprase* 3

yielded a clear, violet-blue glass.

- ζ) Prepared *siliceous earth* . . . 80 grains,  
*Carbonated pot-ash* . . . 60  
*Oxyd of nickel, from the ore of*  
*that metal of Annaberg, ob-* }  
*tained by the process men-* } 3  
*tioned at (e)* . . . }

By this experiment I obtained a glass of a violet-blue colour, perfectly resembling the last.

- η) Prepared *siliceous earth*,  
*Burnt borax*, of each . . . 60 grains of each  
*Oxyd of nickel from chrysoprase* 3

produced a clear, light-brown glass.

- θ) Prepared *siliceous earth*  
*Vitrified phosphoric acid*, pre-  
*pared from bones,* 60 grains of each  
*Oxyd of nickel from chrysoprase* 3 grains,

have afforded a honey-yellow glass; but which did not become entirely clear.

i) Of the various inferences that may be drawn from the preceding facts, I will select only a few.

*Lehmann*, to my knowledge, was the first, who observed that chrysoprase affords a *blue glass* by fusion with carbonate of pot-ash. This observation is confirmed by the experiments of *Achard*, made on the subject of the fusibility of various substances. The foregoing experiment (ε) shews, that this blue colour solely depends on the portion of nickel contained in chrysoprase; and it is proved, by the experiment (ζ), that the oxyd of nickel, if freed, as much as is practicable, from extraneous admixtures, possesses the property of tinging glass-frits, mixed with mild pot-ash, of a *blue* colour, on their vitrification. But what can be the reason, that this blue colour is not produced by means of mild soda employed in the same manner? To what cause is that difference to be ascribed?

The same experiments also prove that *Le Sage* \* was in the wrong, when he asserted that the metallic ingredient in chrysoprase is cobalt. Besides cobalt, we now know several metallic substances capable of producing a blue glass, under certain conditions, with which the chemist should be thoroughly acquainted, before he infers from this the nature of any metallic substance. Thus, *cobalt* covers all fluxes, (enamels, glass-pastes) blue; while *oxyd of wolfram* (tungsten) imparts a blue colour to such frits only as are mixed with phosphoric salts, leaving, on the contrary, those

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\* See *Analyse Chimique et Concordance des Trois Règles*, par Mr. *Sage*, tom. II, Paris, 1786, page 73.



colourless that are combined with borax. In like manner, the *oxyd of nickel* tinges blue the frits prepared with carbonat of pot-ash; but brown, those into which carbonat of soda, or borax, enters; and, lastly, it produces a *honey-yellow* in such as are mixed with a neutral phosphat.

Since, therefore, chrysoprase does not afford a blue, but a *brown* glass, when melted with borax; this fact, together with the knowledge that no trace of any green sympathetic ink is discovered in its muriatic solution, is alone a sufficient evidence of the absence of any portion of cobalt from that fossil. *Le Sage* tells us, indeed, he has produced a blue glass from chrysoprase and borax; but again this assertion of his does not correspond with experience.

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## XLV.

## CHEMICAL EXAMINATION

OF THE

## NOBLE OPAL,

*From Cscherwenitzza, in Upper-Hungary.*

IF the *Noble Opal*, effulgent with variegated colours (*chatoyant*) be contrasted with the colourless *rock-crystal* and the dull, dark coloured *flint*, it would hardly be possible, were it not for the conviction afforded by chemical experience, to be persuaded that the chief constituent part of those three species of stones, so dissimilar in their external appearance, is the same simple, pure, siliceous earth, or, at least, only in exceedingly small proportions, mingled with foreign ingredients; and that it is only the difference in the state of aggregation which modifies the one to opal, the other to rock-crystal, and the third to flint.

But that the *noble opal*\* really belongs to the purest sorts of flint, is demonstrated by the following analysis.

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\* *Estner* has published in his *Mineralogy*, vol. II. page 402 seq. an ample description of this beautiful stone; taken principally from the valuable opals in the Imperial Cabinet at Vienna, so distinguished by their beauty and magnitude; and, besides, from those in the collection of opals of *Abbé Neumann*, Director of the Imperial Cabinet of Medals, which, perhaps, is the most complete in its kind. Of the accurate agreement of those descriptions with the originals, I had the pleasure of convincing myself by my own inspection, at Vienna.



A.

A piece of rough, or unwrought noble opal, weighing  $76\frac{1}{2}$  grains, was exposed to fire, in a well-covered porcelain-vessel. It crackled at the very first degree of heating. When the noise caused by this had ceased, it was kept in ignition for half an hour longer. After cooling, it was found burst into small flat splinters, of a pure milk-white, and a surface partly glittering, partly of an enamel-lustre. The yellowish ferruginous covering, which is perceivable even in the rough stone, and penetrates its extremely minute fissures, was changed, by the ignition, to a *high-yellow-red*, and, in part, *iridescent*, or exhibiting changes of rainbow colours. It experienced a loss of weight of  $7\frac{1}{2}$  grains, or about 10 per cent.

B.

a) *Hundred grains* of rough, noble opal, finely-pulverized in the flint mortar with water, were mixed, after exsiccation, with 200 grains of dry carbonated soda, and subjected to moderate red-heat for two hours, in a silver-crucible.

The mass, which but loosely coalesced, was then triturated, softened with water, super-saturated with muriatic acid, and briskly digested. The fluid formed a gelatinous coagulum as it cooled. When diluted with more water, and again digested, it was filtered, and the *siliceous earth* remaining on the paper thoroughly lixiviated, and ignited, after previous drying. It then weighed 90 grains.

c) The muriatic liquor was reduced to a small bulk by evaporation, and treated with caustic ammoniac, added in  
ex-

excess. But only a very small quantity of brownish flocculi separated, consisting merely of iron, and amounting to  $\frac{1}{10}$  of a grain, when collected and ignited.

But, since the very pure white colour of the ignited opal evidently proved, that this slight portion of iron does not essentially belong to its mixture; and since, besides, not the least perceptible trace of alumine appeared, I can only reckon as real constituent parts, in the opal here examined, the following:

|                      |       |
|----------------------|-------|
| <i>Silex</i> . . . . | 99    |
| <i>Water</i> . . . . | 10    |
|                      | <hr/> |
|                      | 109   |



## CHEMICAL EXAMINATION

OF THE

## SAXON HYDROPHANES\*.

AMONG those varieties of opal, which are known by the names, *hydrophanes*, *changeable opal*, *oculus mundi*, and possess the remarkable property of becoming transparent in water or other fluids, those from *Saxony* are, besides, particularly distinguished by the beautiful opalescent play or change of colours, which they exhibit in that situation, of which some exhibit sensible indications, even in their natural dry state.

Yet, although hydrophanes has been analysed by various persons, the proportions of its constituent parts are stated very differently.—From this disagreement, *Wiegleb* was induced to institute a new examination of this stone, which made it appear, that the argillaceous ingredient, to which that peculiar physical property of hydrophanes has been erroneously attributed, is a much smaller constituent part than has been asserted by various authors.

This investigation, made by *Wiegleb*, does not thoroughly agree with the result of that which I performed with various hydrophanes, kindly given me by Baron *Racknitz*, of *Dresden*, and found at *Selitz*, near *Hubertsburg*. This learned connoisseur and respectable promoter of mineralogical science likewise confirms the circumstance related by *Wiegleb*, that hydrophanes, while in the mine, is soft; and,

\* *Chemische Annalen*, 1790, part I. page 61. *Chemische Annalen*, 1789, part I. page 402,

444 XLVI. *Examination of the Saxon Hydrophanes.*

in this state, susceptible of receiving impressions from hard bodies.

a) One hundred grains of this Saxon hydrophanes were coarsely divided or bruised, and ignited upon red-hot coals, in a small glass retort. At the end of this process there appeared, in the receiver, an empyreumatic water, covered with a thin greasy pellicle. The loss of weight arising from this was  $5\frac{1}{4}$  grains.

b) The ignited hydrophanes was then triturated to a sub-  
tle powder, mixed with twice its weight of carbonated soda,  
and kept in a moderate heat for two hours. When the  
mass had cooled, it was powdered, super-saturated, and  
digested with dilute muriatic acid. This done, the muri-  
atic fluid filtered off from the *siliceous earth*, that had much  
swelled, together with the lixiviating water, was concen-  
trated by evaporation, and saturated with caustic ammoniac;  
by which, however, only a small precipitate was produced,  
consisting of pure *alumine*, unmixed with iron, and weighing  
 $1\frac{5}{8}$  grains after ignition. Nothing farther was found in the  
remaining liquor.

Hundred parts of this *hydrophanes*, from Saxony, there-  
fore contain:

|                                                           |           |
|-----------------------------------------------------------|-----------|
| <i>Silex</i> . . . . .                                    | 93,125    |
| <i>Alumine</i> . . . . .                                  | 1,625     |
| <i>Volatile inflammable parts,</i><br>and water . . . . . | 5,250     |
|                                                           | <hr/> 100 |

If this hydrophanes, after complete expulsion of its aque-  
ous moisture, be steeped in melted wax or spermaceti, in  
which state of artificial preparation it is called *pyrophanes*;  
it acquires the property of being quite translucent, and of a  
brown yellow or grey colour, when heated in a spoon upon  
a charcoal fire.



## CHEMICAL EXAMINATION

OF THE

## WHITE AND GREEN OPAL

*From Kosemütz\*.*

AMONG the different stones that accompany the chrysoprase in its veins, on the mountainous district of *Kosemütz*, there also occur various sorts of opal, which ought to be classed partly with the *common* (dull) *opal*, partly with the *semi-opal*. They are there found chiefly of four colours, viz. green, reddish, yellow, and milk-white; of which the three last varieties belong to the *common-opal*, and mostly lie on a grey and brownish hornstone.

The subject of this enquiry was the *milk-white*, inclining to the *blueish and transparent* variety of that *common-opal*.

a) *Half an ounce* of this fossil, most finely levigated, and intimately mingled with one ounce of desiccated soda, was moderately ignited for two hours. The mass, obtained and ground to powder, was saturated to excess with dilute muriatic acid; then evaporated nearly to dryness, again diluted with water, and finally thrown upon the filter. The residue, lixiviated, dried, and ignited, gave 237 grains of *siliceous earth*.

b) The fluid, diminished by evaporation, and combined with caustic ammoniac, afforded a slight quantity of a brownish

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\* *Beobachtungen und Entdeckungen aus der Naturkunde.* Berlin, 1788. vol. II. page 45.

precipitate.

446 XLVII. *White and green Opal of Kosemütz.*

precipitate. As the remaining liquor continued unaltered, on being combined with carbonat of soda, it shewed, by this, that it held no other substance in solution.

c) When the precipitate, obtained by means of caustic ammoniac, had been redissolved in muriatic acid, and treated with prussiat of pot-ash, it afforded some Prussian blue, of which the *oxyd of iron*, that enters as a constituent part into this opal, was, at most, one-quarter of a grain. After its separation, carbonat of soda still precipitated half a grain of *aluminous earth*, which, upon ignition, could not be estimated at more than one-quarter of a grain.

This *common opal*, therefore, chiefly consists of mere siliceous earth; for *one half ounce* of it yielded :

|                               |                               |
|-------------------------------|-------------------------------|
| <i>Silex</i> . . . . .        | 237 grains.                   |
| <i>Alumine</i> . . . . .      | 0,25                          |
| <i>Oxyd of iron</i> . . . . . | 0,25                          |
|                               | <hr/>                         |
|                               | 237,50                        |
| Loss . . . . .                | 2,50                          |
|                               | <hr/>                         |
|                               | 240 grs. or $\frac{1}{2}$ oz. |

The *apple-green* variety of those opals from *Kosemütz*, which it will be more proper to rank under the *semi-opal*, penetrates like the *chrysoprase*, in clefts or veins, of from one-half to one full inch thickness, those masses of earths and stones, which lie promiscuously in irregular strata in the mountains which afford *chrysoprase*. - The constituent parts of this green *semi-opal* are likewise those of the foregoing common white opal, only that it contains about *one per cent.* of *oxyded nickel*, from which, likewise, its green colour, like that of *chrysoprase*, originates.



## CHEMICAL EXAMINATION

OF THE

*YELLOW OPAL from Telkebanya.*

FOR the analysis of this species of opal, expressed by the name *pitch-opal, telkebanya-stone*, I selected that clear greenish-yellow variety, which in gross splinters resembles the *bright-yellow common amber* (electrum, succinum).

a) Hundred grains of it, broken into coarse fragments, were subjected to red-heat for half an hour in a covered crucible. The stone flew in pieces, with a moderate decrepitation or crackling noise. It was slightly transparent, after this ignition, but only on the edges; its colour also changed into a pale brown-yellow, and the loss of weight, which it sustained, amounted to five grains. At the same time it became very soft, and allowed of being easily ground to a subtle isabella-yellow powder.

A stronger heat renders this opal greyish-white. The slight portion of iron which it contains, and from which it derived its colour, is reduced, in this process, to the reguline state; and, by means of a good magnifying lens, extremely fine grains of iron, that have transfused, may then be discovered\*.

b) The above-mentioned 95 grains of ignited and pulverized opal were mixed with 200 grains of effloresced mild

448 XLVIII. *Yellow Opal from Telkebanya.*

foda, or such as had lost its water of crySTALLIZATION in the air, and in that situation exposed to, and maintained in, a moderate red-heat during the space of one hour. The mixture came out of the fire quite white, and but loosely conglutinated. It was next softened with water; supersaturated with muriatic acid; concentrated by evaporation to a jelly; once more diluted with water; and, lastly, thrown upon the filter. The *siliceous earth*, which, by this management, remained behind on the paper, weighed  $93\frac{1}{2}$  grains, when ignited.

c) I then treated the colourless muriatic fluid with caustic ammoniac, added in an over proportion. But only a few brown flakes separated, which, when collected and ignited, afforded one grain of oxyd of iron. The remainder of the fluid contained no other ingredient.

Accordingly, *hundred grains of this yellow opal, from Telkebanya*, consist of:

|                             |       |
|-----------------------------|-------|
| <i>Silex</i> . . . . .      | 93,50 |
| <i>Oxyd of iron</i> . . . . | 1     |
| <i>Water</i> . . . . .      | 5     |
|                             | <hr/> |
|                             | 99,50 |



## XLIX.

## CHEMICAL EXAMINATION

OF THE

*BROWN-RED SEMI-OPAL**From Telkebanya.*

THIS fossil, which occurs but seldom in the Telkebanya-mountains, and by some has been erroneously considered as a red pitch-stone, possesses a brown-red colour; is massive, and of moderate brilliance. Its fracture is flat conchoidal, and its texture compact and smooth. It is opaque, brittle, and bursts easily. By reduction to a fine pulverulent state, it acquires a fully saturated deep-red colour, similar to that of powdered resin, called dragon's-blood. Its specific gravity I found to be 2,540.

a) When entire pieces of it were strongly ignited for half an hour, in a covered crucible, it neither flew in pieces, nor experienced any change of colour; but it lost  $7\frac{1}{2}$  per cent. of weight.

But when exposed to the more intense heat of the porcelain furnace, the phenomena take place, which have been mentioned in Essay I. No. 65. For, if ignited in the *charcoal crucible*, a great number of grains of iron transude, and the fracture of the stone becomes grey, dull, earthy, very rough and porous, like sponge. If ignited in the *clay-crucible*, its whole surface is covered by a fine-scaly ferruginous crust, of a metallic lustre, and attractible by the load-stone. It is, indeed, an unexpected phenomenon, and hence the more remarkable, that iron, so strongly oxyded as it is when contained in this fossil, has, in the latter instance, been re-

G g

duced

450 XLIX. *Brown-Red Semi-opal from Telkebanya.*

duced to the reguline state, so as to obey the magnet; and this, without any admixture of charcoal, or any other substance of a nearer affinity with oxygen.

b) *Hundred* grains of the fossil, most finely levigated, were mixed with a caustic alkaline lye, containing 300 grains of the salt. This mixture, being first inspissated to dryness in a silver vessel, was then ignited for half an hour. After re-frigeration, I softened the mass with water, super-saturated it to a great excess with muriatic acid; and having inspissated it to a gelatinous consistence, I diluted it again with water, digested and filtered it. The *siliceous earth*, then obtained and ignited, weighed  $43\frac{1}{2}$  grains.

c) The yellow muriatic solution was combined with caustic ammoniac to over-saturation. A quantity of brown *oxyd of iron*, rather in large proportion, fell down, which weighed 47lb. when washed, dried, and ignited. The fluid left by this remained unchanged, when combined with mild alkalis.

d) This oxyd of iron was re-dissolved by digestion, in muriatic acid, and precipitated by Prussian alkali. After the separation of this blue precipitate of iron, the remaining solution was examined, first with caustic ammoniac, and next with mild soda. It suffered no change in either case.

Wherefore this fossil, which, from its large proportion of iron, might, perhaps, deserve to be classed under the genus of iron, with the denomination of *opaline iron stone*, is, in the *hundred*, composed of:

|                     |         |       |
|---------------------|---------|-------|
| <i>Oxyd of iron</i> | . . . . | 47    |
| <i>Silex</i>        | . . . . | 43.50 |
| <i>Water</i>        | . . . . | 7.50  |
|                     |         | <hr/> |
|                     |         | 98    |



L.

## CHEMICAL EXAMINATION

OF

*MENILITE\**.

THE fossil here treated of, and of which *Delabre* and *Quinquet* have given the first notice †, is found at *Menilmontant*, near *Paris*. It there occurs at a depth from 60 to 80 feet under a seam of clay (*Thonbank*), in a stratum of stones that belong to *Werner's polishing slate*, and is found in larger or smaller pieces, for the most part detached, and kidney form, or rather in nodules. The colour of its external surface is a tarnished blue; but its fracture is of a hair-brown, with some greasy lustre. Its texture appears externally foliated or fine-slaty. This, however, is to be considered merely as impressions from the adhering finely-lamellated gangue or matrix; and should be distinguished from the coarse slaty texture of the stone itself, which can only be observed when separate. It readily bursts into fragments, which are flat-conchoidal in the cross fracture, but coarse-splintery in the longitudinal fracture, and are transparent in the edges. It cuts glass, though it greatly yields to the file, which produces a grey-white streak on it. When it is struck with steel, only a few single sparks are emitted. Its specific gravity is 2,185.

In the systematical arrangement of minerals, this stone has formerly been reckoned among the genus of clay, and accordingly placed as a variety of pitch-stone, with the name *blue pitch-stone*. Against this, an anonymous author has

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\* *Chemisch. Annal.* 1790. 2 Th. S. 297.

† *Journal de Physique*, Paris, Sept. 1787.

started some doubts, in a letter to *de la Metherie* †, in consequence of experiments which he has made, by moistening some pieces of the stone, and exposing them for several months to open air; upon which he found, that sulphat of magnesia had gradually been formed. By this he was persuaded, that this species of stone belongs to the magnesian genus, and should be added to the steatites, serpentine and pot-stone. With what propriety, will appear from what follows.

## A.

From the pieces chosen for this enquiry I first separated the earth adhering to their outside. I then introduced *hundred* grains into a small glass retort, inserting its neck into a bottle containing lime-water. The retort was placed between the coals, or in open fire, and the heat gradually increased to the ignition of its contents. At the very beginning there passed over some drops of water, and soon after I saw the lime-water in the receiver growing turbid. In this last, when the receiver had been removed, I perceived a bituminous-empyreumatic smell, which, at first, also seemed to be somewhat ammoniacal. The pieces of the stone in the retort were rendered black and resplendent, like jet (*Gagas*), and had lost eight grains. But by a still stronger ignition in an open crucible, they lost again that black colour, and became at first blueish, then grey-white, losing, at the same time, three grains more in weight.

I then combined them, previously ground to fine powder, with double their quantity of carbonated pot-ash, and put them into an open fire, in a silver crucible. The mixture entered into fusion, without my intending it, and foamed so

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\* *Journal de Physique*, Paris, Fevr. 1789.



strongly that it lifted up the lid of the vessel, and run over in part. Seeing this, I directly withdrew the crucible from the fire, and found that the remaining portion of the mass had melted into a clear greenish glass; which, as it cooled, attracted moisture from the air, and dissolved entirely in a little water.

Although I could not farther proceed in this examination, on account of having lost part of the mass; yet I foresaw, from these facts, that this fossil is not a very compounded species of stone, but rather that it is likely to consist almost entirely of mere siliceous earth. This conjecture was again confirmed by the following experiment.

## B.

a) I reduced *one hundred* grains of the rough stone to an impalpable powder; and having mixed them with twice their weight of carbonated pot-ash, I ignited the mixture in a silver crucible, during five hours, in a degree of heat so moderate, that there was no danger of its fusing. When triturated, it dissolved in water, assisted by heat, leaving only a few undissolved particles. By super-saturation with muriatic acid, the mixture congealed to a thick, intumesced slime. After farther dilution with water, digestion, and filtering, there remained 84 grains of *siliceous earth*, upon being washed, dried, and heated to redness.

b) When the fluid, separated from this last, had been concentrated by evaporation, and, while yet hot, saturated with mild soda, a brownish-white precipitate fell down; which, being re-dissolved in nitro-muriatic acid, there still separated some *siliceous earth*, weighing  $1\frac{1}{2}$  grain, when ignited.

c) The liquor, freed from this, was treated with Prussian alkali; and the quantity of the blue precipitate then produced

duced indicated half a grain of *oxyd of iron*, attractible by the magnet. After the separation of this last, *aluminous earth*, weighing one grain in the ignited state, was thrown down by caustic ammoniac. Carbonated soda, with the assistance of heat, precipitated from the remaining fluid a slight portion of loose earth; which, after ignition, scarcely weighed half a grain, and, upon trial by sulphuric acid, showed itself to be *calcareous earth*, accompanied by a trace of *magnesia*.

In consequence of this analysis, *hundred parts of menilite* contain :

|                                      |       |
|--------------------------------------|-------|
| <i>Silex</i> . . . . .               | 85,50 |
| <i>Alumine</i> . . . . .             | I     |
| <i>Oxyd of iron</i> . . . . .        | 0,50  |
| <i>Lime</i> . . . . .                | 0,50  |
| <i>Water and carbonic matter</i> II, |       |
|                                      | <hr/> |
|                                      | 98,50 |

From the constituent parts here produced, it is obvious, that this fossil can, by no means, belong to *steatites*, or to *serpentine*, or to the *pitch-stone*, as the proportions of those ingredients, in conjunction with the infusibility of *menilite*\*, sufficiently prove. Perhaps this fossil may be considered as a variety of the *semi-opal*, approaching to *flint* (*Feuerstein*).

The inconsiderable trace of *magnesia* does not seem to belong to the mixture or composition of this fossil. It rather originates from particles, that have entered into it from its matrix, which contains a small portion of *magnesia*, as will appear by the following analysis.

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\* See Essay I. No. 69.



## LI.

## CHEMICAL EXAMINATION

OF THE

## POLISHING-SLATE

*(Polierschiefer of Werner.)**From Menil-montant.\**

THE *polishing-slate*, found at *Menil-montant*, which serves as a matrix to the *menilite*, spoken of in the last Essay, possesses a bright white-grey colour; is meager and rough; of a dull earthy fracture; strongly adhering to the tongue; and split, in a slaty manner, by slender horizontal rifts. Its specific gravity is only 2,080. When thrown into water, it imbibes it with a crackling noise, and copious air-bubbles are disengaged. By trituration it affords a very loose powder, which, on ignition, loses 19 in the hundred, and acquires thereby a pale red colour.

I shall not relate in detail the method by which I performed its decomposition, as it was the same with that of the preceding fossil. But I shall only mention the result, according to which the constituent parts of *polishing-slate*, and their proportions to one another, in the hundred, are:

|                     |           |       |
|---------------------|-----------|-------|
| <i>Silex</i>        | . . . . . | 66,50 |
| <i>Alumine</i>      | . . . . . | 7     |
| <i>Oxyd of iron</i> | . . . . . | 2,50  |
| <i>Magnesia</i>     | . . . . . | 1,50  |
| <i>Lime</i>         | . . . . . | 1,25  |
| <i>Water</i>        | . . . . . | 19    |
|                     |           | <hr/> |
|                     |           | 97,75 |

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\* *Chemische Annalen*, 1790. 2ter Theil. Seite 302.

## LII.

## CHEMICAL EXAMINATION

OF THE

*SILICI-MURITE (Meerschaum.)**From the Levant \**

THE plastic *silici-murite* (*myrsen, kil, keffekil*) from *Eski-Scheher*, in *Natolia*, the external characters of which, along with some observations upon it, have been given by *Karsten* †, should, on account of its exterior appearance, be rather added to the argillaceous genus, and in particular to the species of *tripoli*, than to the genus of magnesian earths, under which it has been placed since its analysis, published by *Wiegleb* ‡.

However, as it appears from the paper of *Wiegleb*, that the *silici-murite* decomposed by him was not then in its crude native form, but had been wrought into tobacco-pipe heads, and as from this circumstance it might become doubtful whether the fossil, employed by him in that state, was genuine; I thought it of some use to repeat his enquiry, by analysing some genuine *silici-murite* in its natural state.

For this purpose I selected two varieties; the first of which differed from the other, by a whiter colour, a somewhat smaller degree of hardness, and a greater looseness when powdered.

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\* *Beob. u. Entd. a. d. Naturkunde*, vol. V. Berlin, 1794, page 149.

† *Loc. cit.* page 143.

‡ *Neueste Entdeckungen in der Chemie*, 5 Theil. Seite. 3.



A.

a) The specific gravity of the whiter variety in pure lumps, freed from their porphyraceous matrix, is 1,600. Of this I subjected *hundred* grains to a brisk red-heat in a crucible, by which they lost 30 grains. But, in other respects, they suffered no alteration observable in their external appearance: as, by the result of a previous experiment, hereafter to be mentioned, the loss of weight, which this fossil sustains by ignition, is five parts of water and one of carbonic acid. The above loss of 30 grains is, consequently, divided into 25 grains of *water* and five grains of *carbonic acid*.

b) The remaining ignited 70 grains were ground to a most subtle powder, which I first worked with water to a pulpy consistence. Half an ounce of strong sulphuric acid was then added, and all the fluid distilled over to dryness. The residue being softened with boiling water, its undissolved portion was separated by means of the filter. Which last, edulcorated, dried, and ignited, consisted of  $50\frac{1}{2}$  grains of white, very loose *siliceous earth*.

c) The clear, colourless liquor shewed, by the taste, that it was a solution of *sulphated magnesia*. When concentrated by evaporation, it deposited, as it cooled, a small quantity of selenite, in tender spear-shaped crystals. This being decomposed by mild ammoniac, afforded one grain of carbonated lime, for which half a grain of pure *calcareous earth* must be reckoned.

d) When the selenite or sulphated lime had been separated, the solution yielded, by crystallization, only sulphat of magnesia. From this salt, re-dissolved in water, and decomposed in a boiling heat, by carbonat of pot-ash,  $37\frac{1}{2}$  grains of carbonated

bonated magnesia were obtained, which were reduced, after an hour's ignition, to  $17\frac{1}{4}$  of pure magnesia.

An hundred parts of this whiter filici-murite, therefore, contain:

|                         |    |           |       |
|-------------------------|----|-----------|-------|
| Silex . . . . .         | b) | . . . . . | 50,50 |
| Magnesia . . . . .      | d) | . . . . . | 17,25 |
| Lime . . . . .          | c) | . . . . . | 0,50  |
| Water . . . . .         | a) | . . . . . | 25    |
| Carbonic acid . . . . . | a) | . . . . . | 5     |
|                         |    |           | <hr/> |
|                         |    |           | 98,25 |

I could not ascertain, in the *humid way*, the proportion of the carbonic acid ingredient in this fossil; since acids do not completely dissolve or decompose it in the cold, and hence do not at all effervesce with it, or only imperceptibly. For this reason, I attempted it in the *dry way*. I introduced 200 grains of pulverized filici-murite into a small glass retort, connected with the hydrargyro-pneumatic apparatus, and kept it in ignition until the vessel was near fusing. The water that passed over I collected in the intermediate small spherical cavity of the conducting pipe, while the gas was caught in a receiver above the mercury. The water weighed 35 grains. It was yellowish, and emitted a smell like petroleum; it also manifested an obscure vestige of ammoniac, which, however, was soon after succeeded by a feeble trace of an acid. But the gas, deducting the common air contained in the apparatus, amounted to 13 cubic inches, whose weight is nearly seven grains. This was entirely absorbed by lime-water, from which it precipitated carbonated lime or crude calcareous earth.

## B.

The other sort of filici-murite, the colour of which inclined to the grey, lost 39 grains in the *hundred*, and acquired by it  
the



whiteness of chalk. Its decomposition was performed in the same manner as that of the foregoing. In the result, the following appeared to be its constituent parts in the *hundred*:

|                                   |       |
|-----------------------------------|-------|
| <i>Silex</i> . . . . .            | 41    |
| <i>Magnesia</i> . . . . .         | 18,25 |
| <i>Lime</i> . . . . .             | 0,50  |
| <i>Water and carbonic acid.</i> . | 39    |
|                                   | <hr/> |
|                                   | 98,75 |

Besides these two varieties of filici-murite, I have likewise analysed a third, in which I have found the proportion of magnesia considerably greater, but that of silex much smaller in the same ratio. But as this consisted of one single fragment only, I was not able to repeat the experiment. Yet I mention this, because it shews that Nature does not always observe an invariable proportion in the two chief constituent parts of filici-murite; as, indeed, is also the case with respect to various other fossils.

## LIII.

CHEMICAL EXAMINATION  
OF THE  
*SEMI-INDURATED STEATITES.*

(*Speckstein of Werner.*)

*From Bareuth.*

THOUGH the common *Steatites*, which occurs at *Göpfersgrün*, near *Wunsiedel*, in the principality of *Bareuth*, is found in considerable quantity, yet it has till now been met with only in detached, larger or smaller, reniform lumps. It is distinguished from other species of stones of the same genus particularly by this, that it is found sometimes in hexahedral prismatic crystals, with six-sided pyramidal terminations, and, but very lately, in double hexahedral pyramids\*, imbedded in massive indurated steatites.

a) Two hundred grains of this steatites, finely scraped by the knife, were subjected to red-heat, in a covered crucible, during one hour. They lost by this 11 grains of weight, and the ignited powder of the stone received an isabella-yellow colour.

b) This powder I mixed in a silver-crucible with a caustic lye, of which the alkaline part, or the pot-ash, was double the weight of the pulverized stone; and, after having evaporated it to dryness, I kept it in ignition for half an hour. This mass was again dissolved in water, and digested

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\* This rare crystallization of the *Bareuth-steatites*, resembling the double hexahedral, calcareous, Derbyshire-spar, is found in the collection of Mr. *Frick*, Master of the Mint at Berlin.

with



with muriatic acid, added in excess. *Siliceous earth* was thus separated, amounting to 119 grains, after washing, drying, and ignition.

c) The muriatic solution was combined with carbonat of pot-ash, heated to the degree of ebullition. The brownish precipitate, thereby produced, was treated with muriatic acid; the solution evaporated, and the dry saline mass strongly ignited during half an hour. Having re-dissolved this saline mass in water, and separated the brown oxyd of iron by filtration, I combined the clear solution with carbonated pot-ash, at the temperature of boiling. By these means, 147 grains of very loose and white *magnesia* were precipitated. One half of this, re-dissolved in sulphuric acid, and crystallized, afforded pure sulphat of magnesia. The other half, when heated to redness, weighed  $30\frac{1}{2}$  grains.

d) The brown-red oxyd of iron, that had separated from the aqueous solution of the ignited saline mass (c), weighed nine grains. But, as the portion of iron, existing in the mixture of steatites cannot be considered as perfectly oxyded, but only as being in the state of an oxyd of iron, still attractible by the magnet, I deflagrated linseed-oil upon it, in a covered crucible.—This *oxyd of iron* now weighed only five grains.

According to this analysis, the *Steatites* from *Bareuth* consists, in *hundred parts*, of:

|                                                     |    |           |       |
|-----------------------------------------------------|----|-----------|-------|
| <i>Silex</i> . . . . .                              | b) | . . . . . | 59,50 |
| <i>Magnesia</i> . . . . .                           | c) | . . . . . | 30,50 |
| <i>Oxyd of iron</i> . . . . .                       | d) | . . . . . | 2,50  |
| <i>Aqueous particles</i> , driven out by a red-heat |    |           | 5,50  |

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98

LIV.

## CHEMICAL EXAMINATION

OF THE

## STEATITES FROM CORNWALL\*.

*(Soap-rock, Seifenstein.)*

THE *Steatites* of Cornwall (*Talcum Smectis*, Lin.) occurs at the Cape *Lizard*, in serpentine mountains, which it cuts through in small, perpendicular, or *rake veins*. The finest sort of it is white, with blueish, or reddish spots, resembling marble. While fresh from the mine, it is so soft, that, like soap, it may be abraded with the knife. It is used in making porcelain. The working of these mines is carried on by the House of the Porcelain-manufacture at *Worcester*; which pays 20l. sterling for the ton, at 20 cwt.; because, the bringing it out to the day is extremely uncertain and dangerous, the serpentine rock breaking in so frequently. There also occurs in these mines another sort of it, less fine, and having spots of iron-ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at *Ruan minor*, also in serpentine, there is found, both a grey-white and a light-slate-blue soap-rock, or *steatites*, and also a whitish *steatites*, crossed by calcareous spar, which gives it a smooth, shining fracture.

It was the first, finest sort of *steatites*, that was the subject of the following analysis.

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\* *Beobacht. u. Entdeck. a. d. Naturkunde*, vol. I. Berlin, 1787, pages 163 and 192.



a) One ounce of it, in selected pieces, was exposed to an intense red-heat, placing the glass-retort in open fire. There distilled over a little pure tasteless water. The steatites lost thereby 75 grains, and acquired a somewhat darker colour, and a considerable degree of hardness.

b) It was next, after previous pulverization, intimately mingled and ignited with two ounces of carbonat of pot-ash in a porcelain-pot. The concreted mass was levigated with water, and digested with an over-proportion of muriatic acid. By this, a large quantity of a white, loose, slimy earth, subsided; which, uponedulcoration, drying, and exposure to red-heat, weighed 204 grains, and was pure *siliceous earth*.

c) When the filtered solution had been combined with Prussian alkali, a blue precipitate arose, which I collected, washed, dried, and ignited with a little wax. The whole of it obeyed the magnet, and weighed seven grains; of which, subtracting the portion of iron belonging to the prussiated pot-ash employed,  $3\frac{1}{2}$  grains are the *oxyd of iron*, entering as a constituent part into steatites.

d) From the solution, freed from iron, I now precipitated its earthy ingredient, by carbonated pot-ash. It weighed 192 grains, when washed, and gently ignited. These were covered with a proportionate quantity of distilled vinegar, somewhat concentrated by freezing; and, after this, digested in a low heat, and thrown upon the filter. The earth that remained on the paper, and which weighed 93 grains, when desiccated and ignited, was mixed with three times its weight of strong sulphuric acid; the mixture evaporated nearly to dryness in a sand-heat; the dry saline mass liquefied in water; and, lastly, filtered. By this treatment there yet remained 26 grains of *siliceous earth*.

e) The

464 LIV. *Examip. of Steatites from Cornwall.*

e) The fulphuric solution (d), therefore, contained 67 grains of earth; which, precipitated by alkali, and examined in the usual way, was found to be merely *aluminous earth*.

f) Of the first 192 grains of the earthy precipitate (d), 99 grains were taken up by the acetic acid. These I likewise precipitated by means of carbonated pot-ash. The earth thus obtained was tried by fulphuric acid, and found to be mere *magnesia*.

Therefore *one ounce*, or 480 grains, of this *Steatites from Cornwall* have yielded:

|                               |               |     |   |             |  |
|-------------------------------|---------------|-----|---|-------------|--|
| <i>Silex</i> . . . . .        | b) 204 grs. } |     |   |             |  |
| — . . . . .                   | d) 26 }       | . . | . | 230 grs.    |  |
| <i>Magnesia</i> . . . . .     | f) . . . . .  |     |   | 99          |  |
| <i>Alumine</i> . . . . .      | e) . . . . .  |     |   | 67          |  |
| <i>Oxyd of iron</i> . . . . . | c) . . . . .  |     |   | 3,75        |  |
| <i>Water</i> . . . . .        | a) . . . . .  |     |   | 75          |  |
|                               |               |     |   | <hr/>       |  |
|                               |               |     |   | 474,75      |  |
|                               |               |     |   | Lofs . 5,25 |  |
|                               |               |     |   | <hr/>       |  |
|                               |               |     |   | 480         |  |

Or, an *hundred* parts of it, averaging the small fractions, contain:

|                               |       |
|-------------------------------|-------|
| <i>Silex</i> . . . . .        | 48    |
| <i>Magnesia</i> . . . . .     | 20,50 |
| <i>Alumine</i> . . . . .      | 14    |
| <i>Oxyd of iron</i> . . . . . | 1     |
| <i>Water</i> . . . . .        | 15,50 |
| <hr/>                         |       |
|                               | 99    |



## CHEMICAL EXAMINATION

OF THE

CHINESE AGALMATOLITE.

(*Plastic stone. Bildstein.*)

BY the name *Plastic Stone* (agalmatolithus), I denote that fossil, which hitherto has been called *Steatites* from *China*; since this last denomination of it, as indicating a stone belonging to the magnesian, or muriatic genus, can no longer be retained with propriety, as will appear from the following analysis of that fossil.

The want of rough pieces of this stone I supplied by employing figures cut of it; the genuineness of which is rendered indisputable by the known peculiar taste or *character* of the Chinese art.

On breaking several of these little carved figures, I observed that two varieties may be distinguished of the stone used for them by the Chinese artists; which I denominate the *transparent* and the *opaque*.

A.

*Transparent Chinese Agalmatolite.*

The colour of this is olive and asparagus-green, verging through various shades to a greenish-blue. Inwardly it is very much glittering, and of a greasy lustre. The chief fracture is indistinctly thick-slaty, but the cross-fracture h h evidently

evidently small-splintery. It is strongly transparent, inclining to the semi-translucid; soft, and of a greasy feel, &c. Its specific gravity, 2,815.

a) Two hundred grains of this agalmatolite, finely ground, lost 11 grains of weight by a moderate ignition for half an hour.

b) After the first ignition, the powder of the stone was mixed with equal parts of carbonated soda, and once more subjected to red-heat for half an hour in a silver-crucible. The mixture returned from the fire in the form of a moderately coalesced powder. I diluted it with water, and super-saturated it with muriatic acid; which dissolved the whole of it without leaving any observable residue. But when the solution had been put in a sand-heat to evaporate, it formed a thick gelatinous coagulum; and after digesting it for some time, it was filtered. The collected *siliceous earth*, washed and ignited, weighed  $105\frac{1}{2}$  grains.

c) The muriatic solution, saturated with caustic lixivium, thickened to a milk-white mass. By a slight excess of the alkaline lye, it again dissolved entirely to a limpid, colourless fluid, leaving only a few light-brown, loose flakes, which, upon edulcoration and ignition, weighed four grains.

d) These four grains of brown residue were treated by digestion with muriatic acid. *Siliceous earth*, weighing  $2\frac{1}{2}$  grains in the ignited state, was then separated. This done, the solution was combined with prussiat of pot-ash, and the blue ferruginous precipitate, thereby produced, was collected. Nothing else was found in the remaining fluid. The portion of iron, which it contained before, amounted to  $1\frac{1}{4}$  grain.

e) The



e) The alkaline solution (c) was saturated to excess with sulphuric acid, and then combined, in a boiling heat, with carbonated soda, to precipitate its earthy contents. The earth, thus obtained, was lixiviated and dried; and afterwards depurated by means of distilled vinegar and ammoniac. Upon deficcation, it weighed 122 grains; but upon ignition, only 72. It was found to be pure *aluminous earth*; for, when re-dissolved in sulphuric acid, and crystallized with an adequate proportion of acetated pot-ash, it afforded only sulphat of alumine.

Wherefore, the *transparent* variety of the *Chinese agalmatolite*, calculated for *an hundred* parts, contains:

|                               |    |                  |             |
|-------------------------------|----|------------------|-------------|
| <i>Silex</i> . . . . .        | b) | 52 $\frac{1}{2}$ | }           |
| — . . . . .                   | d) | 1 $\frac{1}{4}$  |             |
|                               |    | 54 . . . . .     | 54          |
| <i>Alumine</i> . . . . .      | e) | . . . . .        | 36          |
| <i>Oxyd of iron</i> . . . . . | d) | . . . . .        | 0,75        |
| <i>Water</i> . . . . .        | a) | . . . . .        | 5,50        |
|                               |    |                  | <hr/> 96,25 |

B.

*Opake Chinese Agalmatolite.*

This variety of agalmatolite is reddish-white, flesh-red, and of variously coloured veins. Its fracture is dull, and less distinctly splintery. It is opake, or only very little transparent on the edges; very soft; and feels very greasy. The specific gravity of it is 2,785.

a) *Two hundred* grains of it, finely scraped off from the mass, sustained a loss of 20 grains by ignition. Its original reddish-white colour was by this process changed to a grey.

h h 2

b) This

b) This ignited powder was a second time exposed to red-heat for half an hour, in a silver-cruible, with its own quantity of deficcated mild soda; which caused it to conglomerate but moderately. The mixture, previously drenched with water, was combined with an over-proportion of muriatic acid, and the solution evaporated to a jelly.—When this had again been diluted with sufficient water, it deposited *siliceous earth*, amounting to 122 grains, when collected on the filtering paper, and subsequently lixiviated and ignited.

c) The muriatic solution was afterwards decomposed by carbonated pot-ash, and the thorough separation of the precipitating earth was promoted by boiling. The precipitate, which subsided in a highly swelled state, was lixiviated, and while yet moist, brought into a warmed alkaline caustic lye; in which it dissolved in an instant, and left only a slight brownish residue.

d) Muriatic acid entirely dissolved this residue. By combination with Prussian alkali, Prussian blue fell down, the quantity of which denoted one grain of *iron* in the stone. The fluid was next, after the separation of the iron, decomposed in a boiling heat by dissolved carbonat of pot-ash, which precipitated a white earth. This last effervesced moderately with sulphuric acid that was poured upon it, and deposited gypsum; the quantity of which increased, in proportion as the volume of the mixture was reduced by evaporation. It weighed, after ignition, five grains, equal to two grains of pure *calcareous earth* in the ignited state. The small quantity of the fluid yet remaining shot into crystals of sulphat of alumine.

e) The portion which had been taken up by the alkaline lye (c) was thrown down by means of sulphuric acid, but  
it



it dissolved again by a slight excess of the solvent. The alum last obtained, (*d*), was then added to it, and the whole precipitated afresh by carbonat of pot-ash, assisted by a boiling heat. When afterwardsedulcorated, dried, purified by means of vinegar and ammoniac, and finally heated to redness, the precipitated alumine weighed 50 grains.

*f*) I then poured sulphuric acid upon it, and inspissated the mixture on a sand-bath. The turbidness of the fluid, on being again dissolved in water, was caused by the tender siliceous earth, which then separated, and consisted of two grains after ignition. This being subtracted, the quantity of aluminous earth (*e*) is reduced to 48 grains; which now, by combination with acetite of pot-ash, and crystallization, continued to the end to shoot into alum only.

It follows, from this decomposition of the opaque variety of the Chinese agalmatolite, that its constituent parts give in the hundred:

|                    |    |    |   |       |       |
|--------------------|----|----|---|-------|-------|
| Silex . . .        | b) | 61 | } | . . . | 62    |
| —                  | f) | 1  |   |       |       |
| Alumine . . .      | f) |    |   |       | 24    |
| Lime . . .         | d) |    |   |       | 1     |
| Oxyd of iron . . . | d) |    |   |       | 0,50  |
| Water . . .        | a) |    |   |       | 10    |
| <hr/>              |    |    |   |       | 97,50 |

Several examples have shewn, that, in the systematical arrangement of fossils, the light of chemistry should be the guide; and I think the present analysis furnishes one of the most conspicuous proofs of that point. The three fossils, which were the subject of this and the two preced-

ing essays, have to this day been considered merely as varieties of *steatites*: and yet, how materially do they differ in their constituent parts, considering that the semi-indurated *steatites* (*Speckstein*), from *Bareuth*, contains, besides its portion of *silex*, merely *magnesia*; that the *steatites* (*Seifenstein*), from *Cornwall*, is composed of *magnesia* and *alumine*; and that the *Chinese steatites* (*Bildstein, agalmatolite*) contains also *alumine*, but not the least trace of *magnesia*. This last, which must now be removed from the genus of *magnesia*, and added to that of *alumine*, seems to be properly placed along with *lithomarga* (*Steinmark*).

Among the other stones, also manufactured by the Chinese into figures, or little statues, I have likewise met with a white, pure, very finely grained *marble*; which, by bare inspection, is sufficiently distinguished from the Chinese *agalmatolite* here treated of.



## LVI.

## ADDITION

TO THE

## CHEMICAL EXAMINATION

OF

*LEPIDOLITE* \*.

SINCE the analysis of *Leucite*, described in the earlier part of this work, has evidently proved that it contains the *vegetable alkali* as one of its essential constituent parts; it was to be expected that this alkaline substance might likewise be found in the mixture of various other species of stones and earths. The first confirmation of this conjecture has been afforded to me by the *Lepidolite*.

In the examination of this stone, here quoted, the loss of weight in the sum of its constituent parts, which I could not then farther account for, amounted to  $6\frac{1}{2}$  per cent. † As I suspected that this loss might arise from the vegetable alkali, which at that time was not yet known as a co-constituent part of fossils, I resolved to undertake a second analysis of lepidolite.

## A.

I reduced, by grinding, 250 parts of the *amethystine red lepidolite* to as fine a powder as the hardness and lubricity of

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\* *Essay* XIX. page 238.

† See *Essay* XXXII. page 355 seq.

its scaly aggregate particles would allow, and digested it with a large quantity of muriatic acid, in a temperature raised at intervals to the point of ebullition. The remaining powder of the stone, when separated from the muriatic solution and washed, was deficcated and ignited. It still appeared, as before, in the form of white, very delicate shining scales, and weighed 210 grains. Treated with the blow-pipe, it fused, nearly as easily as lepidolite in the rough state, to a smooth globule.

b) This circumstance making it evident that the muriatic acid had effected only an incomplete decomposition, I reduced again the remaining powder, by long continued trituration, to the most comminuted state possible, and boiled it once more with a fresh quantity of muriatic acid. The residue separated by filtration shewed now no farther disposition to melt, and seemed to consist of mere siliceous earth.

c) The muriatic solutions (a) and (b) were then evaporated to dryness, in a sand-heat; the saline mass remaining was pulverized, covered with alcohol, and placed in a warm temperature. A considerable sediment settled to the bottom; which, after the spirituous solution had been poured off, was dissolved in water, combined with some drops of ammoniac, and filtered. It then left behind it a brownish slime, consisting of alumine, silice, and oxyd of manganese.

d) I next evaporated the clear solution that had passed the filter. It left behind a saline pellicle, consisting of small cubes; which, after gentle ignition, in order to drive off the small portion of muriated ammoniac existing in it, weighed  $16\frac{1}{2}$  grains. This salt was muriated pot-ash. Dissolved in a little water, and combined with a solution of pure tartareous acid, it formed acidulous tartrate of pot-ash,

(cream



(cream of tartar), which by combustion yielded carbonat of pot-ash.

Now, since in  $16\frac{1}{2}$  grains of muriated pot-ash are contained 10 grains of pot-ash free from water and carbonic acid, there remain 4 grains of this last to be reckoned as constituent parts in 100 of lepidolite.

## B.

a) *Two hundred and fifty* grains of powdered lepidolite were exposed to a red-heat, during two hours, in a silver-crucible, previously mixed with the same quantity of very pure carbonated soda, that had effloresced in the air. This mixture came out of the fire a compactly united mass, of an uniform, lively brick-red. It was pulverized, and supersaturated with dilute muriatic acid, and kept in digestion till the red colour had totally vanished. The *siliceous earth* that subsided from this solution was afterwards separated by means of the filter.

b) The muriatic solution was then evaporated to dryness; the saline mass was extracted, by alcohol, in a low heat; the sediment, left undissolved by this last, was redissolved in water, then combined with a little ammoniac, filtered, and again evaporated to a dry salt.

c) The dry salt, thus obtained, was again dissolved in water, and, in combination with liquid acid of tartar, exposed to a warm temperature. At the beginning, the mixture continued clear; but, gradually, it deposited minute crystalline grains, which, after lixiviation and drying, weighed  $12\frac{1}{2}$  grains. They consisted of *regenerated tartar*, from which carbonated pot-ash was produced by combustion.

d) I now returned to the precipitate, separated by means of ammoniac (*b*). This I dissolved in dilute sulphuric acid; and, after having added to this solution the spirituous solution of the muriated alumine (*b*), as well as the muriatic solution from which the regenerated tartar had been separated, I subjected the whole for some time to digestion; and finally freed it, by filtration, from the remaining brownish, muddy deposit. This solution, when farther evaporated, without any addition of acetated vegetable alkali, shot into regular crystals of alum, amounting to 185 grains. The remainder of it, still farther evaporated, congealed to a shapeless saline mass.

Thus, by the experiment B, the presence of the alkaline saline constituent part in lepidolite has received an additional proof: for, these 250 grains of this fossil yielded as much pot-ash as was necessary to the production of the  $12\frac{1}{4}$  grains of regenerated tartar, mentioned at (*c*), and likewise the quantity entering into the 185 grains of the crystallized alum here obtained.

However, the quantity of vegetable alkali naturally contained in lepidolite is more accurately shewn by the experiment A; according to which, as mentioned in its place (A. *d*), there must be added to its other constituent parts 4 per cent. of pot-ash.

*Hundred parts of Lepidolite, therefore, contain:*

|                                              |       |
|----------------------------------------------|-------|
| <i>Silex</i> . . . . .                       | 54,50 |
| <i>Alumine</i> . . . . .                     | 38,25 |
| <i>Pot-ash</i> . . . . .                     | 4     |
| <i>Oxyds of manganese and iron</i> . . . . . | 0,75  |
|                                              | <hr/> |
|                                              | 97,50 |
| Loss, partly consisting of water             | 2,50  |
|                                              | <hr/> |
|                                              | 100   |

In



LVI. *Second Analysis of Lepidolite.* 475

In my first analysis I noticed my surprise, that, in this very fusible stone, besides the flux and alumine, no constituent part could be found to promote fusion, except the very trifling portion of the oxyds of manganese and iron.

Yet I do not venture to affirm, unconditionally, that this fusibility of *lepidolite* is owing to this alkaline ingredient now discovered in it; because the *leucite*, whose earthy parts are likewise flux and alumine, as well as *lepidolite*, is, in fact, infusible, notwithstanding that it contains the alkaline ingredient in five times the quantity of that of *lepidolite*.

## CHEMICAL EXAMINATION

OF

## URANITE.

—  
FIRST SECTION\*.

1.) THE ancient philosophers, who considered our globe as the center of the material universe; and the sun, on the contrary, merely as a planet destined, like the others, to a periodical circumvolution round the earth, flattered themselves that they had discovered a great mystery of Nature, in the agreement of the *seven celestial bodies*, which they assumed for planets, with the *seven metals* known in those times. In consequence of the various hypotheses which they founded on this supposed mystery, they allotted to each metal a certain planet, by whose astral effluvia its generation and maturation were to be promoted. In like manner, they took from these planets their names and symbols, to designate the metals subordinated to them. But as the above number of metals has long since been increased by later researches; and as the discovery of new planets has not kept pace with that of metals, the metals newly found out have been deprived of the honour of receiving their names from planets, like the older ores. They, therefore, must be satisfied with the name given them accidentally, and, in most instances, by the common miner.

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\* Read in the Royal Academy of Sciences, at Berlin. See *Memoire Chimique et Mineralogique sur l'Uranie*, in the *Memoires de l'Academie Royal des Sciences*, &c. Août, 1786, jusqu'à la fin de 1787. Berlin, 1792.



## LVII. Chemical Examination of Uranite. 477

Of late, *seventeen* metallic substances have been acknowledged as distinct metals, each of a nature peculiar to itself. The design of this essay is to add one to that number, the chemical properties of which will be explained in the sequel\*.

2.) The particular fossil, by the decomposition of which I have discovered this new metallic substance, is the black, or *pitch-blende* (*pseudo-galena* of many) as it has been hitherto called. In the mean time, I shall continue to use that appellation, till, in the progress of this essay, the necessity of giving it a new name will be conspicuous. This fossil is found at *Joachimsthal* in Bohemia, and at *Johann-Georgenstadt*, in the metalliferous mountains of Saxony.

Only a few writers appear to have been formerly acquainted with this mineral. *Wallerius* and *Brünich* mention, indeed, under the head Argentiferous Ores of Zinc, the *pitch-blende*, and a black *pitch-ore* (*Pecherz*); but it does not appear that they meant by it, or even have known the above fossil from *Joachimsthal* and *Johann-Georgenstadt*. *Werner*, to whom its fracture, hardness, and gravity, sufficiently indicated that it could not be a blende, has transferred it from the class of zinc-ores to that of the ores of iron, calling it *Eisen-pecherz*; though only *ad interim*, until its proper place should be ascertained by chemical analysis. A subsequent conjecture of his, that this fossil might, perhaps, contain the metallic radical of *tungsten*, or *wolfram*, was thought to be supported by actual experiments made at

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\* Even this number (17) of metallic substances has received an addition, by the *Titanium*, so lately discovered, as is shewn by *Essay XIV.* pages 200 and 210.

478 LVII. *Chemical Examination of Uranite.*

*Schemnitz*\*. But this pretended fact is contradicted by the result of the following examination.

3.) The varieties of this fossil, that have hitherto occurred, may be divided into two sorts. The *first* of them is found in brownish-black, massive, and, for the most part, outwardly flat, reniform pieces. It is resplendent both externally and internally; wholly opaque, and of an imperfect conchoidal fracture. It is brittle, admits of being easily comminuted by trituration, and affords then a black powder, tending to the greenish. Its specific gravity, upon an average, is 7,500.

To this sort belong, in particular, the pitch-blendes dug at *Joachimsthal*, in the mines, or galleries; *Sächsischer Edelleutstolln*, and *Hohe Tanne*; where they are accompanied by brown-red ponderous spar.

The *second variety*, to which belongs the greatest part of pitch-blende that occurs at *Johann-Georgenstadt*, is greyish black, and exhibits various degradations, from the glittering to the dull or dim. At that place it is obtained in the mine *Georg Wagsfort*, in larger or smaller masses, between strata of schistose mica (*Glimmerschiefer*); which is nearly in a state of decay. It is usually accompanied by a metallic earth (oxyd), of a yellow, reddish, and light-brown colour; and, besides, also frequently by the *green mica*, as it is called, crystallized in small quadrangular tables. Sometimes it is observed to be invested by compact galena (*Bley-schweif*), or having this latter disseminated in its substance in delicate veins and points. It has also been met with there in the mine *Neujahrsmaassen*, between alternate strata of the fibrous brown iron-stone†.

\* See *Bergmannisches Journal*. 1789. Vol. I. page 612.

† A more ample description of its external properties has been given by *Karsten*, in the 4th vol. of the *Beobacht. u. Entdeck. a. d. Naturkunde*. Berlin, 1792, page 178.



LVII. *Chemical Examination of Uranite.* 479

4.) When pitch-blende is tried by itself, before the blow-pipe, it undergoes no alteration, and is perfectly infusible. If mixed with soda, or borax, and placed in the same situation, it is converted into a grey, cloudy button, resembling scorix. But with a neutral phosphat it produces a clear, green globule. If in these trials some minute metallic grains ever appear, they proceed from the lead interspersed in the fossil.

5. a) I exposed *half an ounce* of triturated pitch-blende to a strong red-heat, in a coated glass-retort. After cooling, I found that it had lost seven grains. A small portion of sulphuric acid has also passed over, and in the neck of the retort a little sulphur was observed to be sublimed.

b) Another equal quantity of pitch-blende was roasted in open fire, that is, on a test under the muffle, until all its sulphur had volatilized. By this management it lost 20 grains. Upon this I kept it one hour longer in ignition, and observed that its weight had again increased eight grains.

6.) To examine the relations of pitch-blende to the *fixed alkalis* in the *dry way*, I triturated  $\frac{1}{2}$  ounce of it with one ounce of carbonated pot-ash, and urged the fire to the fusion of the mixture in the crucible. The mass poured out of the vessel was black-grey, compact, hard, and of a lamellar fracture. When ground, boiled with water, and filtered, the powder of the fossil remained on the paper with its former black colour, and also nearly with its original weight. The colourless fluid had merely an alkaline taste, excepting only a slight indication of alkaline sulphuret (*liver of sulphur*); and when saturated with nitric acid, it deposited some flocculi of siliceous earth, weighing four grains.

By

By this insolubility of pitch-blende, in melting pot-ash, it was decided that it in no way belonged to the fossils which contain tungsten, or wolfram.

7.) I now proceeded to examine its habitudes with acids.

*Dilute sulphuric acid* was incapable of effecting a true solution; it only extracted from it a faint greenish tincture. Even *concentrated sulphuric acid* did not entirely dissolve this fossil: for, after  $\frac{1}{2}$  ounce of pitch-blende had been digested with one ounce of that acid, in a retort, the liquor being then again distilled off to dryness, and the residue softened with water, and filtered, its undissolved part still weighed three drachms: and likewise the black colour which it still preserved shewed that no perfect solution had taken place. The fluid that had passed over was sulphureous acid; and the solution filtered off from the residue had a green colour.

8). *Nitric acid*, on the contrary, produced a more complete decomposition of that fossil.

a) *Half an ounce* of the greyish-black, dull pitch-blende was digested, in a low-heat, with moderately strong nitric acid. It was attacked by the acid with an evolution of red nitrous vapours. I affused, by degrees, more of the acid, till the disappearance of the black colour of the fossil shewed that its decomposition was accomplished. The solution, when again diluted with water, was of a bright wine-yellow, variegated with the greenish. It left on the paper a white-grey residue, weighing 16 grains upon desiccation. This took fire, when heated in an earthen pot, and burned with a sulphureous flame; losing thereby  $5\frac{1}{2}$  grains. The remaining  $10\frac{1}{2}$  grains consisted of filix; from which nitromuriatic acid still extracted some portion of iron.

b) One



b) One *half ounce* of the *blackier sort* of pitch-blende, treated in the same manner with nitric acid, coagulated, upon solution, to a bright-green gelatinous consistence, in which some light grey-yellow particles lay dispersed. By dilution with water, and filtration, it left 26 grains of a reddish-grey residue, 6 grains of which were sulphur, and the remainder an earthy matter, impregnated with iron.

c) When no pure, compact lumps can be had, the pitch-blende, which is still embodied with its matrix, may also be employed for extraction with nitric acid. *Twenty-four* ounces of moderately strong nitric acid, affused upon 8 ounces of fragments of this impure pitch-blende, previously pulverized, attacked it with vehemence; the mixture became hot, and emitted red vapours. After digestion for some time, I diluted the solution with water, and filtered it. The *gangue*, or matrix of the *shistose mica* kind, existing in the fossil, remained behind as a light-brown mud; which, after washing and desiccation, weighed  $4\frac{1}{2}$  ounces, but lost one drachm more by burning off the sulphur which it contained. I concentrated the greenish-yellow solution, by distillation, from a retort; by which management nitrat of lead separated, in white granular crystals, amounting to 50 grains.

g) By *muriatic acid* only an incomplete solution was produced.

But if this acid be mixed with one third part of the nitric, the *nitro-muriatic acid* arising from this combination effects a perfect solution.

*Half an ounce* of pitch-blende, mixed with two ounces of aqua regia, became hot, and was violently attacked by this solvent; at the same time that the mixture strongly effe-

vesced, and the solution was almost entirely effected for the greatest part. When it had digested a while, it was diluted with water, and passed through the filter. Its residue weighed 13 grains; which, after the combustion of the sulphur, left nine grains of a filiceous matrix. The solution deposited muriat of lead, while cooling, in minute, white, needle-shaped crystals, which, by reduction, yielded a reguline bead of lead, of  $\frac{3}{4}$  grain. After some time, there appeared in the solution some beautiful, large, bright, greenish-yellow crystals, in rhomboidal six-sided tables.

10.) Endeavouring to become more accurately acquainted with the metallic principle which is the chief ingredient in pitch-blende, as well as with its chemical relations to other substances, I performed various experiments with the nitric and nitro-muriatic solutions before mentioned.

At first I attempted to find whether a *reduction* of it would take place in the *humid way*. With this view, I filled two glasses with those solutions, immersing in the one some polished iron, and in the other a thin stick of zinc. But in neither case was any thing precipitated.

11.) Prussiat of pot-ash threw down, from both these solutions, a *deep-brown-red* precipitate, resembling red sulphurated oxyd of antimony (*Kermes mineral*). This phenomenon is one of the most characteristic properties, by which this metallic substance is distinguished. It is true, copper likewise falls down, of a brown colour, if precipitated from acid menstrua by means of Prussian alkali; but then it appears rather more in the form of flocculi, of a woolly cohesion: whereas the former, on its precipitation, directly spreads, or diffuses itself through the whole volume of the fluid. Still more does the brown-red precipitate, obtained by precipitating the oxyd of molybdena from its  
muriatic



LVII. *Chemical Examination of Uranite.* 483

muriatic solution, by means of Prussian alkali, resemble that mentioned above. However, besides that the colour of this last is brighter, these two metallic substances are, in every other respect, so different, that they cannot easily be mistaken for each other.

If the pitch-blende, as is mostly the case, be accidentally accompanied by a portion of iron, the precipitate appears, at first, of a dirty black, but, after the separation of this, its colour is a purer brown.

12.) *Sulphuret of ammoniac* precipitates the metallic substance of pitch-blende, dissolved in acids, of a *brown-yellow* colour; in which case, the mixture is usually covered by a white-grey pellicle of a metallic lustre.

13.) By *tincture of galls*, or gallic acid, added to excess, only a slight quantity of a blackish precipitate is produced. But if the predominant part of the acid be neutralized by an alkali, a copious precipitation of a *chocolate-brown* ensues.

14.) All *alkalis* throw down the metallic portion from the acid solutions of pitch-blende, of a *yellow colour*. This affords another character peculiar to that metallic substance. The shades, or degradations of that yellow colour, are various, according to the degrees of purity of the fossil, and, likewise, according to the nature of the alkaline salt employed in the process.

The fixed alkalis promote the precipitation, in the most complete manner, if they are used in their caustic, or pure state. The precipitate is then commonly lemon-yellow; but it inclines more to the white, if carbonated alkali is employed as a precipitant.

484 LVII. *Chemical Examination of Uranite.*

15.) If more carbonated alkali be added than is required to saturate the acid, part of the metallic oxyd will be redissolved; but it falls again down, of a lemon-yellow, by saturating the excessive portion of the alkali. A similar redissolution, in carbonated fixed alkali, happens, when the yellow oxyd, recently precipitated and washed, while yet moist, is mixed with deliquesced pot-ash, and digested in a boiling heat. If, to the saffron-yellow solution, after separation of the undissolved residue, nitric acid is added, it throws down the dissolved part of a pale yellow colour.

On repeating this experiment with caustic lixivium, the colour of the metallic oxyd changed to a dark-brown. But this lixivium, being afterwards examined, was found to contain nothing of that oxyd. This circumstance serves to prove that it is not the alkali, but the carbonic acid combined with it, that contributes to effect the solution before noticed.

16.) Somewhat different was the colour of the precipitate which I have obtained from the greenish nitric solution of the blacker variety of pitch-blende (8. b.), by means of caustic soda; for this inclined from the yellow to the green. This is not owing to a latent portion of copper in the fossil; as the precipitate gives neither colour nor taste to caustic ammoniac poured upon it.

17.) This yellow metallic oxyd readily dissolves in acids.

When treated with dilute *sulphuric acid*, gently warmed, it was soon dissolved, leaving only the portion of lead which still remained in it. The solution, duly evaporated, afforded a lemon-yellow metallic sulphat, crystallized in small accumulated columns.

18.) The



LVII. *Chemical Examination of Uranite.* 485

18.) The solution of the yellow metallic oxyd in weakened *nitric acid*, and made to crystallize by evaporation, at first deposited a small quantity of nitrat of lead, and, afterwards, beautiful, clear, oblong, hexagonal tables, of a pleasing, light-greenish colour; some of which were  $\frac{3}{4}$  of an inch long, and  $\frac{1}{4}$  of an inch broad. To preserve these crystals in their original perfection, they must be kept in a closed vessel, as they seem liable to some decay by the access of air.

19.) The solution of this metallic oxyd, prepared by *muriatic acid*, evaporated to the point of crystallization, and left standing in the cold, at first yielded some muriated lead, in fine needles; but, after this, it shot into yellowish-green crystals, the fundamental figure of which appears to be the rhomboidal, or oblique quadrangular table.

20.) By distilled *vinegar*, strengthened by freezing, this metallic calx was dissolved, with the aid of digestion. After gentle evaporation, this solution afforded fine, clear, topaz-yellow crystals, in regular, four-sided, thin columns, with tetrahedral pointed terminations, some of them one inch long. When I subjected some of these crystals to ignition, beginning with a low heat, the metallic oxyd left, after the expulsion of the acetic acid, preserved the same figure, for the most part, which the crystals had originally possessed.

21.) *Phosphoric acid*, likewise, is a solvent of the precipitate obtained from pitch-blende. But this solution does not long continue clear; the phosphated metallic oxyd falling down, by degrees, in yellow-white, amorphous floculi, of difficult solution in water. A similar precipitate also arises on pouring phosphoric acid into the acetic solution of this fossil.

486. LVII *Chemical Examination of Uranite.*

22.) I introduced a mixture of one part of pitch-blende with three of nitre, by successive portions, into a red-hot crucible. The mass foamed much; but only a weak detonation was observable. I kept it in ignition for half an hour, after which I set it aside to cool. It was of a chocolate-brown; and when this mass, liquified with water, had been filtered, the powder of the fossil left on the paper remained of the same colour. The colourless lixivium contained still some undecomposed nitre; and acids caused it to deposit a whitish precipitate, which for the most part consisted of filix.

23.) After these researches, I made some experiments relative to the process of *reduction*.—When the yellow metallic oxyd was tried upon charcoal before the blow-pipe, it exhibited the same phenomena as were mentioned of the crude pitch-blende, (4.); excepting that it acquired a brownish-grey colour by ignition; and that the brownish colour of the globule produced, on its treatment with soda and borax, was purer and clearer than that from the rough fossil: in the same manner as the colour of the green globule arising from its mixture with an alkaline phosphat, in the like process, was more pure and clear.

24.) The trials made by fusion in the crucible gave all exactly such results, as those previous small trials upon charcoal would allow me to expect.

a) One drachm of rough pitch-blende, mixed with  $1\frac{1}{2}$  drachm of calcined borax, together with some charcoal-dust, and covered with muriat of soda; and

b) An equal quantity of rough pitch-blende, mingled with two parts of black flux, and a little muriat of soda, where melted, each separately, in the wind-furnace



LVII. *Chemical Examination of Uranite.* 487

furnace with a strong fire. In both cases the fossil was converted into a black-grey, dim-scoria, without any trace of reduction: only that some metallic grains of lead appeared, originating from the particles of that metal disseminated in the rough fossil.

25.) In the following experiments I employed the *pure yellow precipitate* before mentioned.

a) One drachm of it was mixed with two drachms of black flux, and inserted in a charcoal-crucible;

b) Another drachm was mingled with twice its weight of calcined borax, and likewise put in a crucible made of charcoal; and

c) A third drachm was mixed with 10 grains of charcoal-duft, 20 grains of calcined borax, and two drachms of powdered white glafs.

These mixtures, the crucibles being first luted, were exposed for one hour and a half to the strongest heat of the melting furnace.

The product, which in all three crucibles was nearly the same, consisted of a black vitreous scoria, but exhibited no indication of any metallic button.

26.) Being thus convinced, that the reduction of this metallic oxyd, which I had in view, was not to be accomplished by means of saline and vitrifying substances, I resolved to treat it merely with combustible bodies, after the manner of the assays of manganese. For this purpose, I tritured 120 grains of the yellow metallic oxyd to a paste, with linseed-oil, and caused the oil gently to burn on a

test. There remained 85 grains of a heavy black powder behind; which I exposed, in a well secured charcoal-crucible, to the medium heat of the procelain-furnace.

At the same time, another crucible, containing pure oxyd of *manganese*, and prepared in the same manner, was exposed to the same fire.

When both these crucibles were brought back from the furnace, I found, that, in the *second*, the reduction of *manganese* to the reguline, or metallic state, had been most perfectly accomplished. But in the *first* crucible I found the oxyd, obtained from pitch-blende, in the form of a heavy and only loosely coherent mass; which by friction between the fingers could be divided into a fine black-brown dust, yet possessed of a metallic lustre.

In pouring nitric acid upon a part of that dust, the solution went on with pretty considerable energy; the mixture growing hot, and giving out a quantity of red nitrous fumes. By this phenomenon, I was persuaded, that the oxyd had in some manner been revived to the metallic state, although not run into one mass; and, hence, that this metallic substance is more refractory than even *manganese*.

27.) To experience, whether this oxyd of pitch-blende, thus far metallized, would not perhaps prove more fusible, I put the remaining portion in a charcoal-crucible; covering it with half its quantity of calcined borax, and the remaining space of the vessel with pulverized charcoal. The outer crucible of baked clay, into which the former was inserted, was then well luted, and exposed to the strongest heat of the porcelain-furnace. My expectation, as I found by the result, was not totally disappointed; for I now obtained a coherent mass, consisting of conglutinated extremely



tremely minute metallic grains, whose aggregation, however, was not compact, but finely porous, and like froth. The colour of that metallic mass was outwardly dark-grey, but inclining on the streak to the brownish. Its metallic lustre, for want of perfect density, was but moderate, and the cohesion of its integrant particles only slight. Its specific gravity, 6,440.

No alteration was produced, when small portions of that regulus were ignited upon charcoal with the assistance of the blow-pipe. On fusing it with fusible phosphoric salt, the globule, while melting, was coated with a dull, silvery white pellicle, formed by cohering, exceedingly fine metallic globules. On continuing the fusion, this metallic crust entered deeply into the body of the globule, which at last acquired the appearance of a dim, grey-green, porous scoria.

28.) With the view of attempting an artificial mineralization by sulphur, I mixed the yellow oxyd with twice its weight of sulphur in a small glass-retort, and expelled again from it the greatest part of the sulphur, by applying heat. The residue combined with the rest of the sulphur was a black-brown, compact mass. But the degree of affinity of this metallic substance with sulphur is but low; for, on exposing again this sulphurated mass, in another retort, to the action of fire, the remainder of the sulphur admitted of being entirely driven out; while the metallic part remained behind in the form of a black, heavy, granular powder.

29.) To investigate what colour this metallic oxyd would give to glass-frits, and what effect it would produce on porcelain, when applied to it as an enamel colour, the following experiments were made.

a)

490 LVII. Chemical Examination of Uranite.

- a) *Silex* . . . . . 2 drachms,  
*Mild pot-ash* . . . . . 1 drachm,  
*Yellow metallic oxyd* . . . 10 grains,

produced a clear, light-brown glass.

- b) *Silex* . . . . . 2 drachms,  
*Mild soda* . . . . . 1 drachm,  
*Yellow metallic oxyd* . . . 10 grains,

yielded an opaque, black-grey glass.

- c) *Silex*,  
*Burnt borax*, } of each . . . 2 drachms,  
*Yellow metallic oxyd* . . . 20 grains,

afforded a glass perfectly resembling brown rock-crystal  
 (*Rauch-topaz*).

- d) *Silex*,  
*Vitreous phosphoric acid*, } 2 drachms of each  
     prepared from bones, }  
*Yellow metallic oxyd* . . . 20 grains,

gave a bright apple-green, opaque glass, almost like chryso-  
 prase.

- e) *Vitreous phosphoric acid*,  
     from animal bones . . . 2 drachms,  
*Yellow metallic oxyd* . . . 10 grains,

produced a clear emerald green glass.

These two last vitrifications, by degrees, attracted mois-  
 ture from the atmosphere.

f) The *yellow metallic oxyd*, gently ignited, mixed with  
 a proper flux, and applied to porcelain, and fused upon it



in the enamelling furnace, produced a saturated or deep orange-yellow colour.

30.) From the whole of these experiments it is manifest, that the pitch-blende does not belong either to the ores of zinc, or to those of iron, nor yet to the genus of tungsten or wolfram, and in general to none of the metallic substances hitherto known; but, on the contrary, that it consists of a *peculiar, distinct, metallic substance*. Therefore its former denominations, *pitch-blende*, *pitch-iron-ore*, &c. are no longer applicable, and must be supplied by another more appropriate name.—I have chosen that of *uranite*, (*Uranium*), as a kind of memorial, that the chemical discovery of this new metal happened in the period of the astronomical discovery of the new planet *Uranus*\*.

31.) In the pit *Georg Wagsfort*, at *Johann-Georgenstadt*, the metal *uranium* likewise occurs in the form of a metallic oxyd, of an earthy appearance. This is the earthy fossil, already mentioned at the beginning of this essay, which there accompanies the compact uranitic ore under various shades of colour, passing from the pale sulphur-yellow into the brick-red, as also into the brown-yellow. The light-yellow and reddish varieties are the purest; since, when dissolved in nitric acid, and treated with Prussian alkali, they immediately precipitate of a brown-red colour. The darker varieties, on the other hand, contain more or less of iron. This earthy oxyd of uranium has formerly been taken for an ochre of iron. It has likewise been considered, as the product arising from a previous decay of shistose mica, which forms the gangue, containing this fossil in the mine just mentioned.

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\* This is called *Georgium sidus* in England only.—Transl.

32.) To this place likewise belongs the *green mica*, as it was formerly called, that is also dug from the same pit. This beautiful fossil is found in the fissures, rifts, and partings of the rock, as well as upon the earthy uranitic oxyd; for the most part, in the form of thin quadrilateral tables, some of which approach to the cubical figure. Its colour is variable, passing from the emerald green to that of the green-finch, to a lemon-yellow, and even to the silver-white.—It is also found on the *Tannenbaum* at *Eibensstock*, mostly upon brown hornstone-quarz, though but very sparingly.

33.) It is indeed certain, upon various grounds, that this fossil is not a true mica. Yet its nature continued to be a matter of question, until *Bergmann*, on analysing it, thought that he had discovered in it muriated copper and argil; and it was upon this authority that *Werner* has given it the name *Chalcolite*. Notwithstanding this, *Bergmann* still entertained some doubt concerning the result of his own experiments; especially as he could examine only a very small quantity of it.

34.) But according to my experiments, this green mica, or chalcolite, is a *crystallized oxyd of uranium, coloured by copper*. After having procured, with great trouble, and sacrificing several specimens, a small quantity of exquisitely pure crystals, I poured upon them nitric acid, which dissolved them quietly, and entirely in the cold. Into one part of this solution I dropped nitrated silver; but no turbidness ensued, though *Bergmann* asserts that he has obtained muriat of silver. (Horn-silver).

Into another portion of the solution of the green crystals I introduced a polished steel-spring, and found that it became incrustated with a coppery coating of metallic lustre.

The



LVII. *Chemical Examination of Uranite.* 493

The remainder of that solution was saturated with caustic ammoniac. A blueish-grey precipitate fell down, and the liquor, likewise, assumed a blue colour. I then added as much ammoniac, as was necessary to dissolve all the copper contained in that fluid; after which, I decanted the bright blue solution from the precipitate: affusing upon this last successive fresh portions of ammoniac, until this alkaline fluid was no longer tinged blue. The residue, which had been thus freed from copper, I re-dissolved in nitric acid, dividing the solution into three parts. When a polished watch-spring had been immersed in the *first*, neither copper, nor any thing else was precipitated. By combining the *second* portion with Prussian alkali, a brown-red precipitate sufficiently copious was obtained. From the *third* portion, caustic pot-ash threw down a pure yellow oxyd of uranium.

Copper, however, should not be considered as an essential constituent part of the crystallized oxyd of uranium; since I have not found the least trace of it in another variety, that had a pure wax-yellow colour.

SECOND SECTION.

ANOTHER more pure variety of compact uranite, of a lustre almost metallic, which I afterwards received from *Joachimsthal*, induced me to repeat its analysis.

A.

a) Five hundred grains of this uranitic ore were powdered, and digested in a gentle heat, with nitric acid of a moderate strength. The quantity of the acid employed, not being sufficient to effect a total solution, the mixture appeared like a fluid, rendered turbid by a fine brick-red mud; but which disappeared on the addition of another small portion of nitric acid. The solution became clear, while a light-grey flocculent matter separated, and was of a greenish aspect. The residue collected by filtering weighed

494 LVII. *Chemical Examination of Uranite.*

30 grains after drying. When placed upon a test, gently heated, its *sulphureous* part was consumed with a faint flame; and the remainder proved upon trial to be mere *siliceous earth*, weighing 25 grains.

b) The nitric solution was in part generally evaporated. It deposited nitrat of lead; which, when re-dissolved in water, and combined with sulphuric acid, yielded 35 grains of sulphated lead. These indicate almost exactly 25 grains of *metallic lead*.

After this separation of the lead, the nitric solution gradually shot into longish hexahedral plates of a light-yellow colour, somewhat inclining to the green. This nitrat of uranium, re-dissolved in water, and treated with caustic pot-ash, afforded 440 grains of yellow precipitate.

c) The remainder of the solution, that would no longer crystallize, when tried by Prussian alkali, shewed by the blue colour of its precipitate, that it had been contaminated with iron. This precipitate was then inspissated, driving out the nitric acid by means of heat; after which it left a residue weighing 40 grains. This last, when boiled again with nitric acid, and filtered, left on the paper a red *oxyd of iron*; which, triturated with linseed-oil, and ignited, obeyed the magnet, and weighed 13 grains.

Since, therefore, an *hundred* parts of this ore contain no more than *one* part of *sulphur*, and, on the other hand, *five* parts of *lead*; there remains no doubt, but that this small quantity of sulphur belongs to the lead existing in the ore. For this reason, I no longer consider the black uranitic ore, including its varieties, and taken by itself, as an *ore mineralized by sulphur*, but as an *imperfect metallic oxyd*; that is to say, combined with but little oxygen. This condition, so nearly approaching the metallic state, is the cause why the solution of this oxyd in nitric acid is attended with extrication of heat and nitrous vapours.

Hence,



LVII. *Chemical Examination of Uranite.* 495

Hence, according to what has been said, the shining black ore of uranium from *Joachimsthal* is composed, in one hundred parts, of :

|                                                        |       |
|--------------------------------------------------------|-------|
| Sulphat of lead . . . . .                              | 6     |
| Silex . . . . .                                        | 5     |
| Oxyd of iron, attractible by }<br>the magnet . . . . } | 2,50  |
| URANIUM . . . . .                                      | 86,50 |
|                                                        | <hr/> |
|                                                        | 100   |

B.

With the yellow oxyd, that had been precipitated from the solution of the uranitic nitrat, freed from iron, (A. 6.) I instituted several experiments, with a view of its *reduction*. These, however, did not completely answer my desire, to obtain a pure metallic button, run into a compact mass. Of those experiments, the following is that which has best succeeded.

Fifty grains of this oxyd, when ignited, were formed with wax into a ball, and in a well-closed charcoal crucible exposed to the most vehement heat of the porcelain-furnace, the intensity of which gave 170 degrees in *Wedgwood's pyrometer*. The metallic button obtained weighed 28 grains, and presented a dark-grey, hard, firmly cohering, finely-grained, of very minute pores, and, outwardly, glittering mass. On rasping this with the file, or rubbing it with another hard body, the metallic lustre appeared on the place, thus laid bare, of an iron-grey colour; whereas in the other assays that were less perfect, the streak of the uranitic regulus is usually more verging to the brownish. This metallic button likewise surpassed in specific gravity those before obtained; being, 8,100.

## LVIII.

## CHEMICAL EXAMINATION

OF TWO NEWLY DISCOVERED

## TITANITES.

THE discovery of *Titanium*, in the red Hungarian shörl\*, and in the small hair-brown crystals, from the country about *Passau*†, having so much excited the attention of Chemists and Mineralogists, it was natural to expect, that this new metallic substance would also be found in other places. The event has shewn, that this expectation was not ill founded.

The chemical analysis made at *Paris* by *Vauquelin* and *Hecht*, with a fossil, discovered by *Miché* and *Cordier* at *St. Yrieux*, in the department of *Haute-Vienne*, has shewn, that this metallic substance is likewise a native of France ‡.

To this the present essay affords a new addition, by giving the analysis of two other *titanites*, but lately discovered.

## FIRST SECTION.

*Titanite from Spain.*

I HAD the pleasure of receiving from the collection of *Baron Racknitz* at *Dresden*, which is particularly rich in

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\* See *Essay* XIV. page 200.

† *Essay* XV. page 211.

‡ *Journal des Mines*. Paris. No. XV. page 10.



Spanish minerals, a fossil whose outward characters justified the suspicion, that it might be an ore of Titanium.

It occurs at *Cajuelo*, near *Vuitrago*, in the province of *Burgos*.

The internal colour of it is a light reddish-brown, inclining in some places to the copper-red; but externally it is coated with white clay. It seems to have the form of a hexahedral column, with a flat six-sided pyramidal termination; but instead of the actual point, it has a regular excavation, which resembles an inverted, hollowed, hexahedral pyramid. In the inside, that fossil has a strong semi-metallic lustre. Its cross-fracture is very distinctly straight lamellar; and its longitudinal fracture imperfectly and small conchoidal. It is very little transparent on the edges; brittle, very hard, and of difficult levigation, by which it affords a greyish-brown powder. The specific gravity of it is = 4,180.

One hundred grains of it, finely ground, and mingled with 600 grains of mild pot-ash, were brought to fusion in a crucible. The melted mass was of a pearly-grey, which, upon re-dissolution in hot water, deposited the *oxyd of titanium* of a perfectly white colour. When this had been filtered off from the colourless alkaline fluid, and lixiviated with water, till the washings no farther indicated any trace of alkali, it was desiccated, and found to weigh 175 grains.

This titanic oxyd readily dissolved in muriatic acid, and was precipitated from it of a permanent green, by Prussian alkali, and of a lively brown-red, by gallic acid; and in general, in all its other properties, it agreed with the white oxyd of titanium, extracted from the red Hungarian shörl.

## SECOND SECTION.

*Titanite from Aschaffenburg.*

WITH the foregoing titanite from Spain another fossil corresponds, which Prince *Dimitri Gallitzin* has found several years past not far from *Aschaffenburg*, in the *Spefsart* forest, preserved in his collection as a mineral not yet ascertained.

Its interior colour is a deep reddish-brown; externally it passes somewhat into the lead-grey, and exhibits silver-white scales of mica adhering to it. The specimen, here examined, was a rounded prismatic, and, as it appeared, a four-sided crystal; the alternate angles of whose facets seemed to be obtuse, and the ends apparently not yet completely crystallized. Its fracture exhibits a strong semi-metallic splendour. The longitudinal fracture is straight foliated; the cross fracture, imperfectly conchoidal. It is untransparent, brittle, and very hard. Its specific gravity was found to be 4,055.

One hundred grains of this titanite were finely powdered, and fused with 600 grains of carbonated pot-ash. The mass, when fixed by cooling, presented a greenish surface, and a pearly grey fracture. Upon pulverization, and solution in water, the filtered alkaline liquor was likewise greenish, but soon lost its colour. The lixiviated and dried oxyd of titanium weighed 166 grains. Its white colour had a little of a reddish tinge, arising, perhaps, from a small portion of manganese; the traces of which were shewn by the external greenish colour of the melted mass, as well as afterwards by that of the alkaline liquor.

As for the rest, the metallic oxyd obtained from this fossil of *Aschaffenburg* exhibited in every respect the same habitudes or relations, as the preceding from *Spain*, or that which had been separated from the *Hungarian* titanite.



## LIX.

## CHEMICAL EXAMINATION

OF SOME

*FERRUGINOUS TITANITES.**FIRST SECTION.**Iron-shot Titanite from Cornwall.*

WITHIN a few years a fossil has been brought into notice by the name *Menachanite*, which has been found in the parish of *Menachan*, in *Cornwall*, and consists of grey-black, sand-like grains, obeying the magnet. Mr. *McGregor*, of *Menachan*, who dedicates his study to mineralogical chemistry, has given not only the first information of this fossil, but also a full narrative of his chemical researches concerning it. The chief result of these is, that menachanite has for its constituent parts iron, and a peculiar metallic oxyd of an unknown nature\*.

By the following examination it will appear, that this substance, which, besides iron, forms the second chief component principle of menachanite, is precisely the very same which constitutes the Hungarian red shörl; namely, oxyd of titanium. With this opinion also, most of the phenomena, noted down by *McGregor*, in his operations with menachanite, agree.

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\* *Crell's Chemische Annalen*. 1791. vol. I. pages 40 and 103.

Though I was easily convinced of this fact by my own experiments, it seemed, on the other hand, very difficult to separate entirely the iron from the titanick oxyd; and, hence, to ascertain the true proportion of these two ingredients to each other. Passing over various experiments which I made with this design, I will relate only the two following, by which I obtained the oxyd of titanium, freed the most from iron.

## A.

a) Two hundred grains of menachanite, finely powdered, were mixed with ten times their quantity of a lixivium, composed of equal parts of caustic pot-ash and water. This mixture, being inspissated to dryness in a polished iron-pot, lodged in a sand-bath, was afterwards ignited in open fire. The mass ran into thick fusion, and assumed in cooling a dirty dark-green colour.

b) By dilution with water, it gave a greenish solution, from which a dark cinnamon-brown powder subsided, which, detained on the filter,edulcorated, and dried, appeared very loose, and weighed 374 grains.

c) The green alkaline fluid soon lost its colour, and deposited some brown flakes, which upon trial were found to be an impure oxyd of manganese, and weighed half a grain. When this liquor had been treated with an over-proportion of muriatic acid, and again neutralized with carbonated pot-ash, it afforded a whitish precipitate, which afterwards was decomposed into seven grains of ignited *silica*, and two grains of oxyd of titanium.

d) The 374 grains of brown-powder (b) were mixed with six ounces of muriatic acid of ammoniac, and sublimed in a retort.



retort. The sal-ammoniac volatilized of a strong yellow. The residue had the form of a loose, isabella-yellow powder, and was found to be still contaminated with iron. When freed from this metal by previous lixiviation with water, and subsequent digestion with muriatic acid, it was of a grey-white, after a repeated washing and drying, and amounted to 168 grains.

e) This grey-white metallic oxyd, proving insoluble in acids, was fused in a crucible with five times its quantity of carbonated pot-ash, and poured out. After congelation, the saline mass presented a pearly white; was compact, and of a coarse-striated fracture. On triturating, and washing it with water, the metallic oxyd was left behind of a perfectly white colour. This, whenedulcorated and dried, weighed 276 grains, and shewed itself in every respect to be a completely pure *oxyd of titanium*.

f) To obtain the iron, I dissolved in water the sublimed muriat of ammoniac (*d*), mixed the solution with the water employed foredulcorating the residue, which thereby became muriated, and then I saturated the whole with caustic ammoniac. The brown *oxyd of iron*, thus separated, was dried, drenched with linseed-oil, and heated to redness. It weighed 100 grains, and was rapidly and entirely attracted by the magnet.

## B.

I effected another complete decomposition of menachanite in the following shorter way.

a) Two hundred grains of menachanite were prepared for their decomposition in the same manner as explained before at (A. a, and b); and the light-brown powder, thus obtained, was ignited for half an hour in a crucible. It now

k k 3

received

received a blackish chocolate-brown colour, and weighed 260 grains.

b) After having affused upon it three ounces of muriatic acid, I evaporated it in a porcelain vessel to a moderately desiccated mass; the colour of which was yellow, like the yolk of eggs, and mixed with orange-yellow. It was then diluted with water, and put on the filter. The filtered liquor contained muriated iron, and the washed residue exhibited on the paper a fine, heavy powder, of an isabella-yellow, which, dried in a low-heat, weighed 106 grains.

c) I mixed this with a quintuple portion of carbonated pot-ash, and brought it into fusion in a crucible. The mass, when poured out, and fixed by refrigeration, was of a pearl-grey, with some light-brownish spots. Upon triturating, and edulcorating it with water, the titanic oxyd remained behind as a flocculent, yellowish-white powder, amounting to 226 grains, when desiccated in the air.

d) This oxyd readily dissolved in muriatic acid, and entirely, without leaving any residue. However, it was not perfectly free from iron; since the precipitate produced from it by the infusion of galls did not exhibit that deep-yellow-red-colour, which is peculiar to the pure gallated oxyd of titanium. On this account, I caused the solution to boil upon a sand-heat; by which management the titanic oxyd separated from the liquor in the form of white gelatinous flocculi. It was then collected on the filter, and lixiviated with water, until this last was no longer blackened by gallic acid.

e) The titanic oxyd, again desiccated, appeared now of a bright yellow colour, and was not attacked by acids in its present state. To render it again soluble, I ignited, and urged



urged it by heat to fusion, with five times its quantity of carbonat of pot-ash. The pearl-grey mass, then produced, and softened by warm water, deposited the metallic oxyd of a perfectly white colour, weighing 230 grains, after edulcoration and drying. Muriatic acid readily dissolved this oxyd, which now, upon trial, appeared to be pure oxyd of titanium, absolutely free from all iron.

f) The fluids, that held the muriated iron in solution, were combined with caustic ammoniac; and the oxyd of iron precipitated by that means, when moistened with linseed-oil, and ignited, was found to weigh 102 grains.

With regard to the proportion of titanium to iron in menachanite, it cannot be determined in the direct way. The reason of this is, that the weight of the separated oxyd of titanium varies very much, according to the different degrees of saturation with oxygen, and perhaps also with carbonic acid; and moreover, according to the degree of deficcation, &c. With greater certainty may the state of the iron contained in menachanite be determined; which seemingly agrees with that of *Ethiops martial*, or black oxyd of iron, attractible by the magnet. Allowing this, the constituent parts of *Menachanite* in the hundred may be assumed as follows:

|                                                   |       |
|---------------------------------------------------|-------|
| <i>Oxyd of iron</i> , attractible by the magnet . | 51    |
| <i>Oxyd of titanium</i> . . . . .                 | 45,25 |
| <i>Silex</i> . . . . .                            | 3,50  |
| <i>Oxyd of manganese</i> . . . . .                | 0,25  |
|                                                   | <hr/> |
|                                                   | 100   |

C.

In order to become acquainted with the habitudes of menachanite in fire, I subjected it to the following experiments.

к к 4

a) Exposed

a) Exposed in a *charcoal-crucible* to the fire of the porcelain-furnace, it proved infusible. Its grains were rendered somewhat more porous; its black colour had become paler, and its lustre less brilliant. At the same time its surface was found overlaid with minute grains of iron.

b) But in the *clay-crucible*, the menachanite entered into perfect fusion, and in this state was imbibed by the pores of the vessel; the places of which, that had been penetrated by the melted fossil, were externally brown, but in the fracture black and resplendent.

## SECOND SECTION.

### *Ferruginous Titanite from Aschaffenburg.*

MENACHANITE is not the only instance of a fossil composed of the oxyds of iron and titanium. Besides that from Cornwall, similar mixtures occur in various countries, differing only in the proportions of their respective ingredients. A proof of this is afforded by the following examination of a fossil, which Prince *Dimitri Gallitzin* has likewise found in the *Spessart* forest, near *Aschaffenburg*, together with the pure titanite described and examined in the preceding section. The specimens given me for the sake of this enquiry, by that zealous promoter of mineralogical science, are of various sizes; the largest is two inches long, one inch broad, and half an inch high. Most of them are free from the *veinstone*, or matrix; but some are embodied in a grey, flat-conchoidal quartz (*Fettquarz*). Their colour is iron-black, accompanied outwardly by a moderate, but inwardly by a stronger, metallic lustre. The fossil itself is compact and opaque. Its fracture is uneven, and of a fine grain; its fragments indeterminately angular. It is very brittle, hard, and is only with difficulty ground to a subtle powder



powder, which has a black colour. Its specific gravity is 4.740.

By the magnet this fossil is not in the least attracted, not even its smallest splinters; nor does it itself attract the least particle of iron. The more remarkable is it, therefore, that it is possessed of the property of indicating, like the loadstone, the adverse poles, by contrarily attracting and repelling either end of the poles of the magnetic needle, or any moveable magnetic bar.

a) One hundred grains of the fossil, finely pulverized, were boiled down to dryness upon a sand-bath, in a polished iron-crucible, with two ounces of alkaline lye, one half of which consisted of caustic alkali. The vessel was then placed between burning charcoal, urging the heat to the ignition of the mass; whereby it fused with the consistence of a thick syrup. The refrigerated mass was of a dirty brownish hue. On being softened with water, its undissolved part subsided as an incoherent, reddish-brown powder, weighing 144 grains, after washing and desiccation. The alkaline liquor was destitute of colour, and had taken up nothing of the fossil.

b) Upon these 144 grains a sufficient quantity of muriatic acid was poured, and again evaporated from it nearly to dryness. On diluting this combination with water, an isabella-yellow precipitate fell down from it. This last, collected on the filter, edulcorated, and dried, and then heated to fusion with five times its quantity of carbonated pot-ash, yielded a grey-white mass, from which, after dilution with water, I obtained a yellowish-white powder, which, cleared by washing from the saline particles, and desiccated, weighed 45 grains. It also, when accurately examined, shewed evidently, that it was *oxyd of titanium*.

c) The

c) The portion of iron, suspended in the muriatic solution, was precipitated by caustic ammoniac, and, when collected, it was moistened with linseed-oil, and subjected to a low red-heat. This iron weighed 78 grains, and the whole of it obeyed the magnet.

As, therefore, no other constituent part existed in the fossil, I may fairly consider the remaining part as its *titanic* portion. According to which, an *hundred* parts of the fossil contain :

|                  |     |       |
|------------------|-----|-------|
| Oxyd of iron     | . . | 78    |
| Oxyd of titanium | . . | 22    |
|                  |     | <hr/> |
|                  |     | 100   |

### THIRD SECTION.

#### *Ferruginous Titanite from Ohlápian.*

##### A.

AT the works at *Ohlápian*, in *Transylvania*, where auriferous sands are washed, there occurs a *titanite* mixed with less iron. It consists of compressed, or flat, rounded grains, for the most part of the size of a lentil, in which, now and then, slight traces of a destroyed crystalline form are observable. Its colour is greyish-black, inclining to the brownish-red. It is opaque; externally of a middling, internally of a brighter, metallic lustre; of a lamellar texture; very hard, brittle; and reducible, by grinding, to a greyish-brown powder. Its specific gravity is 4.445.

If heated alone before the blow-pipe, it suffers no sensible alteration. Nor does the magnet shew any action upon this fossil, either in the rough state, or roasted.

This



This fossil is one of the mingled heterogeneous parts constituting the auriferous sands at Orlápián, which consist of very unequal grains, as well with regard to their shape or form as to their bulk. Of these accumulated sands, the larger grains consist, for the greatest part, of this titanite ore.

The middle-sized grains are partly light-crimson, partly carmine-red. They are opaque, and have half a line, ( $\frac{1}{24}$  of an inch) in diameter. They bear great resemblance to spinell, or, on account of their conchoidal fracture, to the ruby, or red sapphire.

The smallest of them, which seem to be *grains of quartz*, are yellowish-white, very transparent, or semi-pellucid, acute angular, and in their diameter hardly  $\frac{1}{128}$  part of an inch wide.

Of this last size there exist also many fine black grains in the general mass, which probably are likewise *titanium*.

These, and the granular quartz, constitute by far the greatest part of the whole. The mingled heap, from *one sixth* to *one fourth* part, consists of the red grains; but the larger titanite grains lie but sparingly distributed among them.

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a) *Two hundred grains* (by weight) of these minute titanites, previously pulverized, were mixed with a lixivium made of 600 grains of caustic pot-ash in a silver vessel, and after being evaporated to dryness, gently ignited for half an hour. This mass came out of the fire of a verdigris colour, with brown-red speckles. When diffused in water, and passed through the filter, it left on the paper a loose, bright, and brown-red powder. The filtered alkaline li-

quor had at first a deep-green colour, but which soon disappeared; and it deposited *oxyd of manganese*, weighing four grains after ignition. When this precipitate had been removed, I saturated the fluid with muriatic acid, which threw down a whitish precipitate, turning yellow upon desiccation, and consisting of *oxyd of titanium*.

b) This brown-reddish powder I boiled in a sand-heat with muriatic acid, evaporating it afterwards nearly to dryness. By this treatment the mass assumed a yellow colour, like the yolk of eggs. It was in the next place diluted with water, and the white *oxyd of titanium*, separating from the fluid, was collected on the filter.

c) This oxyd, being lixiviated and desiccated, together with the titanite oxyd obtained at (a), was mixed and fused in a porcelain-vessel with six times their weight of carbonated pot-ash. This united mass, when re-dissolved in hot water, deposited a very white, pure *oxyd of titanium*, now soluble in all acids; which in this state of purity, and after washing and desiccation, amounted to 275 grains.

d) Caustic ammoniac precipitated the *oxyd of iron*, that was held in solution by the muriatic fluid (b). This being collected, washed, and exposed, with some linseed-oil, to a gentle red-heat, was found to weigh 28 grains.

On calculating by the method noticed in treating of menachanite, it appears that an hundred parts of this fossil from Ohlapián consist of:

|                                    |       |
|------------------------------------|-------|
| <i>Oxyd of titanium</i> . . . . .  | 84    |
| <i>Oxyd of iron</i> . . . . .      | 14    |
| <i>Oxyd of manganese</i> . . . . . | 2     |
|                                    | <hr/> |
|                                    | 100   |



## B.

By this difference discovered in those three fossils, with respect to the proportion of their two chief constituent parts to each other, their classification in the mineralogical system is rendered somewhat difficult.—If the predominant constituent parts be assumed as the basis of a mineralogical arrangement, the fossil from *Oblâpiân* will take its place as a species of the titanium genus, under the name of *sidero-titanium*; but the *menachanite*, together with the fossil from the *Spefsart*, would constitute a new species belonging to the genus of iron, and obtain the denomination of *titansiderum*.

To conclude: as, besides in the fossils here treated of, I have discovered in various others, of the genus of iron, some traces of this new metallic substance (as, for example, in the small *magnetic iron-grains from Ceylon*, which are often found there in considerable quantity, on washing the collected hyacinth, and other small loose fragments of gems), it is necessary, that for the future, in the more accurate examinations of the iron stones and ores of iron, regard should also be had to *titanium*, as one of their possible ingredients.

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## LX.

## CHEMICAL EXAMINATION.

OF THE

GARNET-SHAPED ORE of *Manganese*.

IN the granitic rocks of the *Spessart*, near *Aschaffenburg*, whose chief aggregate parts are coarse-granular fel-spar, most frequently of a flesh-red, grey-quarz, and a little silvery-white mica; there likewise sometimes occur, as accessory ingredients, some black prismatic fhörls, but, still seldom, a fossil, hitherto unknown; the analysis of which I have made the subject of the present essay, and which, in the mean time, I designate by the name of *garnet-shaped ore of manganese*.

The merit of its discovery belongs to *Prince Dimitri Gallitzin*; and that of the description of its external characters, here subjoined, to *Mr. Karsten*.

“ The varieties of this fossil most recently collected possess a *deep-hyacinthine red* colour, which, in some, changes to the *reddish, or yellowish-brown*; and some burst pieces, that appear to have already suffered some decay, are inwardly spotted *greenish*.

“ Their form of crystallization is not quite distinct; no perfect crystals having been yet found. But to judge from the fragments inspected, as well as from the casts, (the originals of which exist in the cabinet of *Prince Gallitzin*), their leading figure seems to be a *double eight-sided*.



*Of the Garnet-shaped Ore of Manganese.* 511

“ *sided pyramid*, sharpened off on both ends with four sur-  
“ faces. This pointed termination is *more flat*, and all  
“ the angles are *more rhombic*, than in the garnet. Their  
“ edges are partly without truncation, and partly in a re-  
“ versed order; so that two and two joined to each other  
“ have their faces formed by the truncation, but the third  
“ remains entire. Those crystals are in part of a *middling*  
“ size, in part *small*, and *very small*, all of them *imbedded*  
“ in granite.

“ Externally they are *finely*, and, as it seems, *alternately*  
“ *striated*.

“ At the same time they are *shining*. The smallest va-  
“ rieties alone, in which the striæ almost entirely escape  
“ observation, are strongly resplendent, of a lustre between  
“ the gloss of fat and the brilliancy of the diamond.

“ Internally, (where the fossil is undecayed) it is through-  
“ out *very resplendent*, of a fine diamond lustre.

“ Its *fracture* is in *two directions*; namely, those which  
“ correspond with the striæ, *straight-laminated*; but in all  
“ other directions, making an angle with the striæ, *small*  
“ *conchoidal*.

“ The *fragments* appear to be angular, of an indefinite  
“ form.

“ In those specimens which I have before me, I do *not*  
“ perceive *detached* or *insulated pieces*.

“ The fossil is also *strongly transparent*, more or less, on  
“ the edges.

“ *Semi-*

512 LX. *Analysis of the Garnet-shaped*

- " *Semi-indurated*, in a higher degree than pitchstone;  
" *Very brittle*; and *not particularly heavy*.  
" Its *specific gravity*, at a mean ratio, I have found to  
" be 3,600."

A.

a) Ignited by itself upon charcoal, this fossil is by degrees converted into a round greenish-black globule.

b) By borax it is gradually dissolved into a clear olive-green pearl.

c) Neutral phosphoric salt acts upon it only in a languid and imperfect manner, and forms with it by solution a very rifted globule, of a faint amethystine tinge. If nitre be projected upon it, while red-hot, the salt remaining upon the charcoal, after detonation, acquires some deep amethyst-red spots.

B.

a) *Hundred* grains yielded, by grinding to fineness, a reddish-yellow powder. This was covered with a lye containing 300 grains of carbonated pot-ash; and when previously inspissated to dryness, it was subjected to red-heat. The ignited deep-green mass, diffused in water and filtered, afforded a lixivium of the same colour. By saturating it with nitric acid, its green colour was changed to a red. When exposed to a warm temperature, all its colour disappeared, and the fluid deposited brown flocculi, which, collected, weighed  $4\frac{1}{2}$  grains.

b) The



b) The lixiviated residue was of a deep black-brown, and weighed, upon desiccation, 141 grains. Nitric acid, with which it was digested, shewed by itself alone no solvent power upon it; but attacked it only when I added sugar to the mixture. The black-brown colour of the mixture disappeared; and from the solution, now become clear, *siliceous earth* separated, amounting to 35 grains, upon edulcoration and red-heat.

c) To the clear, bright-yellow, nitric solution, caustic ammoniac was added to excess of saturation. A light-brown precipitate ensued. The remaining colourless fluid, reduced by evaporation to a smaller volume, continued unchanged, on combining it with carbonated pot-ash.

d) I re-dissolved this precipitate (c) in muriatic acid, and treated the solution, first with less caustic pot-ash than was required to neutralize the little predominant portion of uncombined acid. Upon this, I added to it a solution of 400 grains of tartrate of pot-ash (*tartarus tartarizatus*), which produced a copious, straw-yellow precipitate, in fine grains. The whole mixture was again evaporated to dryness, then strongly ignited in a porcelain-crucible, and the black-brown residue was lixiviated with a sufficient quantity of water.

This residue, when dried again, together with the preceding, of  $4\frac{1}{2}$  grains (a), was once more ignited. It then appeared in the character of a fine *oxyd of manganese*, and weighed 49 grains.

I digested once more this manganesian oxyd with nitric acid, adding successive portions of sugar, and, lastly, diluting the mixture with water, and filtering it. On the paper there remained *oxyd of iron*, which, edulcorated, and heated

514 LX. *Analysis of the Garnet-shaped, &c.*

to redness, weighed 14 grains; and, after a second ignition with wax, was quickly attracted by the magnet. By deducting this, there remain, therefore, 35 grains for the *oxyd of manganese*.

f) The water employed to lixivate the ignited mass (d) exhibited now a colourless alkaline solution. When fully neutralized with muriatic acid, and treated with carbonate of soda, a white, loose earth was precipitated, which,edulcorated and ignited, weighed  $14\frac{1}{2}$  grains. This earth, dissolved in sulphuric acid, and, when made to crystallize by proper management, afforded, throughout the process, crystals of *alum*.

Wherefore, *hundred parts of this garnet-shaped ore of manganese* have yielded:

|                          |    |   |    |    |       |
|--------------------------|----|---|----|----|-------|
| <i>Oxyd of manganese</i> | e) | . | .  | .  | 35    |
| <i>Oxyd of iron</i>      | .  | . | e) | .  | 14    |
| <i>Silex</i>             | .  | . | .  | b) | 35    |
| <i>Alumine</i>           | .  | . | .  | f) | 14,25 |
|                          |    |   |    |    | <hr/> |
|                          |    |   |    |    | 98,25 |



## LXI.

## CHEMICAL EXAMINATION

OF THE

## NATIVE OXYD OF TIN.

*(Tin-stone. Zinnstein).*

## FIRST SECTION.

*Experiments in the dry way.*

THE *assay of tin*, or the process of producing metallic tin in the *dry way*, by reviving a small quantity from the tin-ore, (called *Tin-stone*) or the *native oxyd of tin*, with the least possible loss of weight, has hitherto been subject to many difficulties. I have always obtained unequal, and hence uncertain results, in the repeated experiments, which I have made, according to the directions given in the elementary treatises on *Docimasy*, or *Art of assaying Metals*; that is to say, by combining the tin-ores to be assayed with fixed alkalis, with borax, and the like. The cause of this failure chiefly depends on the solubility of the oxyd of tin in the alkaline additions, employed as fluxes in the process.

On the contrary, the following *assays*, performed in the simplest manner, without any addition, and merely in charcoal-crucibles, have always given me much more certain, and, on repeating them, constant results, with the exception of an inconsiderable difference.

## A.

*Affays in charcoal-crucibles.*

1.) *Brown, crystallized tin-stone (Zinngrauen)* from *Schlackenwalde*, in *Bohemia*, of the specific gravity of 6,760. One hundred grains of this, in entire pieces, were introduced into the cavity of a charcoal-crucible, closing its orifice with a stopper of the same materials. This charcoal-crucible was then tightly inserted and fastened in another of baked clay, placed upon the forge-hearth before the nozzle of the bellows, and the contents of the first, reduced to the reguline state, by directing thither a brisk current of air for half an hour. The metallic button of tin produced was a little blackish on its sides, and its surface coated with a greenish crust. It weighed  $72\frac{1}{2}$  grains.

2.) *Light-brown, acicularly crystallized tin-stone (Needle-tin)* from *Polgoath*, in *Cornwall*.

The present differs from the many other varieties of Cornish tin-stones in this, that it is an aggregate of very minute, for the most part capillary, four-sided columnar crystals, of a light-brown colour, and vivid lustre. Where the accumulation does not pass into compact tin-stone, the small interstices are filled up by chlorite.

The specific gravity of this oxyd of tin, in crude lumps, is 5,845; but when in the state of picked and well washed ore (*Schlich*), it is 6,750.

Hundred grains of this washed needle-tin, reduced in the charcoal-crucible, in the same manner as the foregoing, afforded a button of metallic tin, weighing 77 grains, with  
some



some superincumbent scoriaceous globules; which weighed two grains, and were probably some remnants of chloritic earth.

3.) *Crystallized grey tin-stone*, having some white transparent spots, from *St. Agnes*, in *Cornwall*. The specific gravity of these crystals is 6,840. One hundred grains, treated in the same manner, yielded 74 grains of revived tin.

4.) *Stream-tin* (*Seifenzinnstein*) from *Ladock*, in *Cornwall*. One hundred grains of this ore, consisting of loose blackish grains, and of the specific gravity of 6,560, were reduced in this way to 76 grains of reguline tin.

5.) *Stream-tin*, from *Altenon*, in *Cornwall*.

The colour of this, which must be reckoned among the purest tin-ores, is in some places darker, in others lighter. Of all the tin-stones, which I have weighed on the hydrostatic-balance, I have found the present the most ponderous; its specific gravity being 6,970.

The reduced, or metallic tin, obtained from hundred grains of this ore, weighed 76 grains.

6.) *Wood-tin*, from *Cornwall*.

This remarkable species, which till now is only known in shivery loose fragments, or *ratchill* of the miners (*Geschieben*), occurs in the washing works of tin, in the neighbourhood of *St. Colomb*, *Roach*, and *St. Denis*, in *Cornwall*; but in small quantities only. Usually the pieces are but small; those that have the size of a bean belong to the scarcer ones\*.

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\* A specimen of wood-tin, of the scarcest magnitude, exists in the exquisitely fine collection of *Baron Racknitz*, at *Dresden*. It is two inches long, and one broad.

This ore, the only one of its kind, is externally distinguished from the common tin-stones, chiefly by the total absence of any crystalline form; while, on the other hand, it exhibits its peculiar, bundled or fascicular fracture. Its external characters have been fully described by *Werner*\* and *Karsten*, chiefly†.

I found the specific gravity of wood-tin-stone to be 6,450.

One hundred grains of it, reduced in the manner already mentioned, viz. simply in the charcoal-crucible, gave 73 grains of reguline tin.

By the same method, I have subjected to the *process* of *reduction* various other tin-stones, as well as washed and pounded tin-ores, and have constantly obtained, in the result, from 72 to 77 *per cent* of reguline tin. The small portion of iron, commonly contained in tin-stones, usually sticks to the surface of the reduced tin, in very minute grains; and it is owing to this, that the button of tin is moved when the magnetic needle is approached to this part of its surface.

It is worth remarking, that usually small cavities are formed in the button of revived tin, as it cools and becomes fixed; which small fissures are covered by minute lamellæ, that, in colour and brilliancy, resemble polished gold in a very illusive manner.

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\* *Beobach. u. Entdeck. a. d. Naturkunde.* vol. I. Berlin, 1787, page 152.

† *Ibidem*, vol. IV. 1792, page 397.



B.

*Habitudes of Tin-stone, when exposed to heat in a crucible made of clay.*

1.) *Brown-tin-stone* from *Schlackenwalde*, exposed to a porcelain-fire, in a baked clay-crucible, ran into a clear dense glass, greenish-grey in the middle, but of a bright yellow on the sides, and at top. The surface was invested with a dull whitish crust. The interior sides of the vessel were glazed of a milk-white, and overlaid with many small groups of light-brown, tender, needle-shaped crystals. The inner surface of the crucible lid, had also similar detached crystals adhering to it.

2.) *Needle-tin* from *Polgooth*, subjected in a clay-crucible to the heat of the porcelain-furnace, likewise produced a compact, light-brownish, transparent glass; covered on the upper surface with a brownish, dim, and shrivelled, or furrowed crust.

3.) *Stream-tin* ore from *Altenon*, committed in the same manner to the porcelain-furnace, in a crucible of baked clay, yielded a compact light-yellow, and still somewhat clearer glass, that was found coated by a dull crust, of an isabella-yellow.

SECOND SECTION.

*Experiments in the humid way.*

THE extreme resistance which tin-stone opposes to acid menstrua has hitherto always prevented the complete success of its decomposition in the *humid way*; the reason of

must be sought for in the highly intimate and difficultly destructible combination of tin with oxygen. To be dissolved in acids, tin indeed, like other metals, requires a commensurate proportion of oxygen. But if that proportion be exceeded, as is the case with tin-stone, with *putty* or *tin-ashes* (the white, perfect oxyd of tin by ignition with access of air) with the oxyd of tin corroded by nitric acid, and similar other calces of that metal; the solution cannot take place, unless the excess of oxygen causing this impediment be previously removed.

## A.

Till the present period, *Bergmann*\* was the only author, who has shewn a method of analysing tin-stone in the humid way: but unfortunately, I, as well as other chemists†, have sufficiently experienced its imperfection. However, I entertained a hope, that the process recommended by him would most likely succeed when employed for wood-tin; on the ground, that of all tin-stones, this at least yields in some manner to the attack of acids; as I observed that 60 grains of it, reduced to an impalpable powder, and subjected to vigorous and long continued digestion with three ounces of nitro muriatic acid, had lost five grains of weight.

For this purpose, I digested 120 grains of finely pulverized *wood-tin*, for some time, with *one* ounce of concentrated sulphuric acid, and the assistance of a boiling heat. After this, I added by degrees two ounces of muriatic acid, and

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\* *Opuscula Physica et Chémica*. vol. II. page 437.

† *Chemische Annalen*. 1786. 2 Band, page 126.



having digested it once more, I diluted the whole with water, and decanted the clear fluid from the undissolved residue which settled at the bottom. The same process was repeated twice with this last, adding each time half the above mentioned quantity of the acids. That portion, which continued insoluble, retained its original appearance, and weighed still 98 grains. The solution exhibited a yellow colour. When part of it was tried by Prussian alkali, the blue tinge manifested some latent portion of iron. The whole of the solution was, upon this, saturated with carbonated pot-ash; which produced a dirty white precipitate, weighing 27 grains in its dry state. Muriatic acid poured upon this precipitate rapidly dissolved it; and, on plunging into the solution, diluted with water, a thin stick of metallic zinc, there settled round it subtle lamellæ of reguline tin.

Yet, although, in this way the solution of *wood-tin* was in part accomplished, it would not succeed with other species of tin-stones, treated in the same manner. Such acids, as have been employed for this purpose, dissolved indeed the small portion of iron entering into the fossil, but exhibited seldom a slight trace of dissolved tin; and the powder of the tin-stone, subjected to the experiment, sustained only a very slight alteration in its appearance and weight.

Besides this, another circumstance connected with this method is yet to be remarked; which is, that each time, when muriatic acid is poured on the concentrated and heated sulphuric acid, clouds of muriatic vapours arise, detrimental to the health of the operator.

Therefore the problem, to decompose, in the *humid way*, tin-stones, and other calces of tin, fully saturated with oxygen, has by no means been solved by the process prescribed by *Bergmann*.

## B.

Among those substances, which, by their near affinity with oxygen, afford a rational conjecture, that, by depriving tin-stone of part of its oxygen, they might prepare or render it fit for its solution in acids, *fulphur* principally seemed to deserve the trial.

*Hundred* grains of finely powdered *tin-stone*, from *Schlack-enwalde*, mixed with an equal quantity of *fulphur*, were introduced into a small glass-retort. This being connected with a receiver, was lodged in a sand-bath, and gradually heated to an incipient ignition of its contents. When this process was accomplished, I found the *fulphur* sublimed, without any change in its natural state; while the residue, which preserved the former white-grey colour of the pulverized tin-stone, was hardly conglutinated, but had here and there some solitary, very minute, glittering, golden-yellow scales of *aurum musivum* spread on its surface. This residue was strongly digested with muriatic acid. But although the muriatic fluid, separated from it by filtering, had, on combination with alkali, afforded some oxyd of tin; yet its quantity was too inconsiderable, to make it reasonable to expect in this way a complete solution of tin-stone.

## C.

After the above mentioned, and several other unsuccessful attempts, I proceeded to the application of *caustic-potash*. It was with satisfaction, that I found in this the means of accomplishing my purpose: so fully, that at present the complete analysis of *tin-stone* in the humid way is no longer subject to any difficulty.



1. a) One hundred grains of tin-stone from *Alternon*, in *Cornwall*, previously ground to a subtle powder, were mixed in a silver-vessel with a lixivium containing 600 grains of caustic pot-ash. This mixture was evaporated to dryness in a sand heat, and then moderately ignited for half an hour. When the grey-white mass, thus obtained, had been softened while yet warm, with boiling water, it left on the filter 11 grains of an undissolved residue.

b) These 11 grains, again ignited with six times their weight of caustic pot-ash, and dissolved in boiling water, left now only  $1\frac{1}{4}$  grain of a fine yellowish-grey powder behind.

c) The alkaline solution (a and b), which was in some degree colourless, was saturated with muriatic acid. A brilliant white, tender oxyd of tin was thrown down, giving to the mixture a milky appearance. This precipitate, re-dissolved by an additional quantity of muriatic acid, was precipitated afresh by means of carbonated soda. When lixiviated and dried in a gentle heat, it acquired the form of bright-yellowish, transparent lumps, having in their fracture a vitreous lustre.

d) This precipitate, being finely powdered, soon and entirely dissolved in muriatic acid, assisted by a gentle heat. Into the colourless solution, previously diluted with from two to three parts of water, I put a stick of zink; and the oxyd of tin, thus reduced, gathered around it in delicate, dendritic laminæ of a metallic lustre. These, when collected, washed, dried, and fused, under a cover of tallow, in a capsule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

e) The

524 LXI. *Chemical Examination of Tin-Ores.*

e) The above mentioned residue of  $1\frac{1}{4}$  grain, left by the treatment with caustic pot-ash (b), afforded with muriatic acid a yellowish solution; from which, by means of a little piece of zink introduced into it,  $\frac{1}{2}$  grain of tin was still deposited. Prussian alkali, added to the remainder of the solution, produced a small portion of a light-blue precipitate; of which, after subtracting the oxyd of tin now combined with it, hardly  $\frac{1}{4}$  of a grain remained, to be put to the account of the iron contained in the tin-stone, here examined.

In these experiments, (excepting only a slight indication of *silex* amounting to about  $\frac{1}{4}$  of a grain), no trace has appeared, either of tungstenic oxyd, which some Mineralogists have supposed to be one of the constituent parts of tin-stone, nor of any other fixed substance. Therefore, what is deficient in the sum, to make up the original weight of the fossil analysed, must be ascribed to the loss of oxygen; and the constituent parts of *pure tin-stone from Altonon* are to each other in the following proportion:

|                         |       |
|-------------------------|-------|
| <i>Tin</i> . . . . .    | 77,50 |
| <i>Iron</i> . . . . .   | 0,25  |
| <i>Silex</i> . . . . .  | 0,75  |
| <i>Oxygen</i> . . . . . | 21,50 |
|                         | <hr/> |
|                         | 100   |

2.) I repeated the same experiment with washed *needle-tin* from *Polgooth*, and obtained nearly the same result.

3.) *Hundred grains of brown tin-stone from Schlackenwalde*, decomposed in the same manner, by means of caustic alkaline lye and muriatic acid, yielded 75 grains of reguline tin; but its portion of iron amounted to  $\frac{1}{2}$  grain.



## LXII.

## CHEMICAL EXAMINATION

OF THE

## NATIVE SULPHURET OF TIN\*.

(Tin-pyrites. Zinnkies.)

THE *Tin-pyrites*, or *sulphuret of tin*, which at *Wheal Rock*, in the parish of *St. Agnes*, in *Cornwall*, at the depth of 20 fathoms under ground, forms a vein of 9 feet in thickness, is the first, and as yet the only instance of a natural tin-ore mineralized by sulphur. *Bergmann*†, it is true, mentions such an ore as coming from *Siberia*; but it has never yet been found there; and what this celebrated chemist has considered as such, and examined, was not a true fossil, but a supposititious product of art ‡.

The colour of this tin-pyrites is grey, of various degradations from the light to the dark, and in the purer specimens approaching to the silvery white. It is found in small lumps, possesses a moderate metallic lustre, and exhibits an uneven, small-grained fracture. Its texture appears to be foliated, and its fragments are, for the most part, indeterminately an-

\* *Beob. u. Entdeck. a. d. Naturkunde.* vol. I. pages 155 and 169.

† *Opusc. Phys. et Chem.* vol. III. page 158.

‡ *Crell's Chem. Annalen.* 1790. vol. I. page 53.

gular.

gular. It is also very brittle, and easily triturated\*. Its specific gravity, as I found, is 4,350.

According to the following analysis, the constituent parts of this ore are *Tin, Copper, Iron, and Sulphur*. For this reason, the name of *Bell-metal ore* has been given it, not very improperly.

Tin pyrites contains, besides the copper chemically mixed with it a sone of its constituent parts, likewise copper-pyrites; which in part is coarsely, and in part finely disseminated in it. From this accidental ingredient, I previously freed, as much as possible, the tin-pyrites, or native sulphuret of tin, subjected to the following examination.

A.

*Half an ounce* of tin-pyrites was heated to redness in a small glass-retort. In the receiver a moisture was found, making about two drops, impregnated with sulphureous acid. The neck of the retort became thinly lined with a little grey and yellow sublimate, of about  $\frac{1}{4}$  grain of weight; which, when placed on a glowing coal, first smelled and burned like sulphur; but after this, a faint odour of arsenic was perceptible. The tin-pyrites lost three grains of weight.

B.

*Two drachms* of tin-pyrites were roasted in a calcining-pot, till no longer any sulphureous smell could be observed.

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\* A more detailed description of the external properties of tin-pyrites, by *Karsten*, may be seen in *Beob. u. Entd. a. d. Naturkunde*. vol. IV. page 391.



By this the ore was converted into a red calx or oxyd, weighing two drachms and 20 grains. It was then mingled with equal parts of calcined borax, half a part of white glass, and one fourth part of colophony. Being introduced in this state into an assay-crucible (*Tute*), lined with powdered charcoal, and covered with common salt, it was kept in a state of strong fusion for half an hour: by which treatment it yielded a metallic button of a grey colour, 10 grains in weight, but very brittle; so much so, that by a gentle stroke with the hammer it flew in pieces. The remainder of the reduced metal lay dispersed in small grains among the pulverulent scoriæ, mingled with the charcoal-dust, that was employed to line the vessel.

## C

a) Two drachms of finely triturated tin-pyrites were treated with an aqua regia, composed of one ounce of muriatic and  $\frac{1}{2}$  ounce of nitric acid. Within 24 hours the greatest part of the metallic portion was dissolved in it, without application of heat; while the sulphur rose up, and floated on the surface of the menstruum. After the mixture had been digested upon it for some time in a low sand-heat, I diluted it with water, and filtered it. It left 43 grains of sulphur on the paper, still, however, mixed with metallic particles. When the sulphur had been gently burnt off on a test, there still remained 13 grains; of which eight were dissolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted one grain of it.—What remained was part of the siliceous matrix, and weighed three grains.

b) The solution of the metallic portion (a) was combined with carbonat of pot-ash; and the dirty-green precipitate,

pitate, thus obtained, was re-dissolved in muriatic acid, diluted with three parts of water. Into this fluid a cylinder of pure metallic tin, weighing 217 grains, was immersed. The result was, that the portion of copper contained in the solution, deposited itself on the cylinder of tin; at the same time that the fluid began to lose its green colour, from the bottom upwards; until, after the complete precipitation of the copper in the reguline state, it became quite colourless.

c) The copper thus obtained weighed 44 grains. By brisk digestion in nitric acid, it dissolved, forming a blue tincture, and left one grain of tin behind, in the character of a white oxyd. Thus the portion of pure copper consisted of 43 grains.

d) The cylinder of tin, employed to precipitate the copper, now weighed 128 grains; so that 89 grains of it had entered into the muriatic solution. From this, by means of a cylinder of zinc, I re-produced the whole of its dissolved tin, which was loosely deposited on the zinc in a tender dendritical form. Upon being assured, that all the tin had been precipitated, I collected it carefully, lixiviated it cleanly, and suffered it to dry. It weighed 130 grains. I made it to melt into grains, having it previously mixed with tallow, and under a cover of charcoal dust, in a small crucible; which done, I separated the powder of the coal by elutriation. Among the washed grains of tin, I observed some black particles of iron, which were attracted by the magnet, and weighed one grain. Deducting this, there remain 129 grains for the weight of the tin. By subtracting again from these last those 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (*b*), there remained 40 grains for the portion of tin contained in the tin-pyrites examined. Hence, including that one grain of  
I tin,



tin, which had been separated from the solution of the copper (c), the portion of pure tin contained in this ore amounts to 41 grains.

The *educts*, or substances, extracted in this process from tin pyrites, were consequently :

|                         |            |
|-------------------------|------------|
| Sulphur . . . . .       | 30 grains. |
| Tin . . . . .           | 41         |
| Copper . . . . .        | 43         |
| Iron . . . . .          | 2          |
| Vein-stone, or gangue . | 3          |
|                         | <hr/>      |
|                         | 119        |

Which makes in an *hundred* parts :

|                   |       |
|-------------------|-------|
| Sulphur . . . . . | 25    |
| Tin . . . . .     | 34    |
| Copper . . . . .  | 36    |
| Iron . . . . .    | 2     |
|                   | <hr/> |
|                   | 97    |

However, this proportion of the constituent parts is not always constant. The darker varieties of tin-pyrites, in particular, are considerably poorer in tin; as, from one of them I scarcely obtained one half of the above quantity of reguline tin : but their proportion of iron increases.

#### D.

Although, in the course of these experiments, no trace of any silver, or lead, which had been suspected to exist as an ingredient in this fossil, had appeared; yet, for the sake of greater certainty, I instituted the following trial. The tin-pyrites, that had been ignited in the retort (A) was treated with nitric acid; which attacked it, emitting co-  
m m
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pious red vapours. After sufficient digestion, I diluted the mixture with water, and separated the remaining sulphur and oxyd of tin by means of the filter; combining, afterwards, the clear, blue solution, both with muriatic and sulphuric acids. But, by its continuing clear and unchanged, it shewed that neither silver nor lead are present in this ore.

## E.

The ready solubility of tin, contained in this ore, in the nitro-muriatic, as well as in the muriatic acid, which does not take place in tin-stones, and all other oxyds of tin fully saturated with oxygen, is a sufficient proof that, in this ore, the tin held in solution by the sulphur, in a manner, approaches the state of native, or reguline tin. This is farther corroborated by the following experiment.

1. a) I exposed *half an ounce* of tin-pyrites, mixed with the same quantity of corrosive sublimate, to a sand-heat, in a small retort, connected with a receiver. At the very first moderate action of the fire, a heavy fluid passed over, attended with heavy white vapours; and, on the increase of heat, a grey-yellow sublimate, for the most part crystallized in needles, settled on the neck of the retort; at the same time that on its upper convexity an impure black-grey cinnabar, or sulphuret of mercury, deposited.

b) The strongly-fuming fluid in the receiver, which gave out thick white fumes, weighed one drachm, and perfectly resembled common *fuming liquor of Libavius*, or sublimed solution of muriat of tin. From this, by dilution with water, and saturation with pot-ash, the oxyded tin was thrown down, as a white, very tumid precipitate, which,edulcorated and dried, weighed 30 grains.

c) The



c) The sublimate, separated from the neck of the retort, was pulverized, digested with water, and filtered. The residue which it left on the paper amounted to 203 grains, when desiccated. These were dissolved in nitro-muriatic acid, with the exception of 15 grains of sulphur; and the mercury fell down, in the reguline state, from the solution, by putting copper into it. The aqueous solution of the sublimate, obtained by the digestion, and precipitated by carbonat of pot-ash, afforded 16 grains of oxyded tin; which were added to the preceding (b).

d) The oxyd of tin was then dissolved in muriatic acid, and again precipitated, in the metallic state, by a piece of zinc, plunged into the solution. This reguline tin, when collected, washed, and melted with tallow, weighed 20 grains. I flattened it by beating with the hammer; cut it into pieces; digested it with nitric acid; and dropped Prussian alkali into the fluid, filtered off from the oxyd of tin. The few brown flocculi precipitated by that alkali, proved that the muriated tin had carried along with it a slight portion of copper.

2.) By way of a comparative experiment, I repeated this process with a species of pure *tin-stone*; but, in this case, not the least trace appeared of any solution of the tin. The mercurial sublimate volatilized in its usual needled form, and the tin-stone remained in the retort unaltered.

## LXIII.

## CHEMICAL EXAMINATION

## OF THE

## MOLYBDAT OF LEAD,

(Yellow Lead-ore),

From BLEIBERG.

## FIRST SECTION\*.

1.) THE yellow lead-ore, or *Molybdat of Lead*, from *Bleiberg*, near *Villach*, in *Carinthia*, constitutes, in the genus of lead, a particular, very distinguished species of ore, occurring in many beautiful varieties. Its colour is waxy-yellow, of various shades; some inclining to the reddish, others to the whitish-grey. For the most part it is crystallized in tables, of from four to eight sides, which sometimes stand singly on their edges, or narrow sides, and, at times, are cellularly concreted. Those specimens of it are rather scarce in which the crystals form a cube, or an octahedron, instead of a table.

The matrix, in which this ore is imbedded, is a compact lime-stone, of a yellow, whitish, or grey colour.

2.) Most mineralogists seem to have become acquainted with this lead-ore, only since the time that *Jacquin*† published his treatise on it; after whom *Wulfen*‡ has contri-

\* *Beob. u. Entdeck. a. d. Naturkunde.* vol IV. 1792, page 95; and vol. V. 1794, page 105.

† *Miscellanea Austriaca.* vol. II. Vienna, 1787.

‡ *Xav. Wulfen. Abhandlung vom Kärnthner Bleispathe.* Wien, 1785.



LXIII. *Analysis of the yellow Lead-ore, &c.* 533

buted to the knowledge of this ore, by the elegant and accurate description which he has given of it. As to the constituent parts of the yellow lead-ore, the following experiments will shew that the substance with which the lead is combined in this mineral is not the oxyd of tungsten, as has been erroneously supposed, but the oxyd of molybdena.

3.) The first point which I had in view, was to separate this lead-ore carefully from the adhering extraneous parts. Finding that diluted nitric acid shewed in the cold no action on this fossil, I affused upon the quantity of it destined for this analysis small portions of this acid; pouring it off again as soon as the effervescence ceased. This process I repeated, till, at last, no more effervescence ensued on adding a fresh portion of the acid. Upon this the ore was washed with water, and desiccated. The nitric acid employed for this purification contained the calcareous earth proceeding from the matrix, which outwardly adhered to the ore, and formed gypsum with sulphuric acid, by means of which I precipitated it. At the same time, a considerable portion of a fine, red iron-ochre was washed off by this process, which dissolved by digestion in muriatic acid, leaving a slight residue, consisting of lead-ore and siliceous earth.

4.) *Two drachms* of the above-mentioned crystals of lead-ore, thus purified, were mixed with an equal quantity of carbonated pot-ash, and exposed to the fire in a small crucible. It entered into fusion without effervescence. The refrigerated mass exhibited a faint reddish tinge, and was covered on its upper part with scales, resembling litharge. Having softened this alkaline mass with water, and filtered, I saturated the colourless solution with nitric acid. By this the mixture was not rendered very turbid; but, on the next day, I found the bottom of the glass covered with

tals of  $\frac{1}{4}$  of an inch long, standing upright; which I examined as follows:

- a) Their figure consists of small, brilliant, accumulated rhomboidal tables.
- b) On the tongue they manifest a weak metallic taste.
- c) Under the blow-pipe, upon charcoal, they fuse very quickly and calmly into little globules, or drops, which are instantly imbibed by the ignited coal.
- d) In the silver spoon they melt into grey spherules, which become shrivelled as they cool; and, during the current of air, urged through the blow-pipe, they deposit a white substance, which covers the spoon.
- e) When put upon a globule of alkaline phosphat, fused on the charcoal, they are rapidly dissolved, and tinge it either of a grass, or olive-green, according to the quantity in which they are added.
- f) They entirely dissolve in water, by the assistance of heat.
- g) Prussian alkali produces from this solution a copious, flocculent precipitate, of a *light-brown* colour.
- h) If, into the aqueous solution (*f*) a little muriatic acid be dropped, and a small piece of tin be put into it; or, if some of those crystals are immersed in a muriatic solution of tin; in both these cases the fluid acquires a *deep-blue* colour.

In consequence of these appearances, I think I do not err in considering these crystals as *molybdic acid*, neutralized by



pot-ash; because, in a comparative experiment, the same relations were shewn by molybdic acid, that had been prepared from molybdena of *Altenberg*, by detonation with nitre, and subsequent precipitation, effected by nitric acid, from the filtered solution of the mass produced by the detonation, and which acid likewise assumed a crystalline form in drying.

5.) As it was obvious, from the state of the calciform lead, which remained on the paper when I filtered the solution of the fused mass (4), that the whole of the yellow lead-ore employed had not been decomposed, I repeated the experiment, increasing, however, the proportion of the alkali; so that, for two drachms of the ore, I took 10 drachms of carbonated pot-ash. I also kept the mass for a somewhat longer time in fusion; after which it was poured out, levigated, softened with water, and thrown upon the filter. This alkaline solution I saturated with muriatic acid, at first only incompletely; whereby, at a warm temperature, a white precipitate was produced, in the form of a cheesy coagulum. This precipitate contained, indeed, molybdic oxyd, but mixed with a greater portion of oxyded lead; which last, upon solution in muriatic acid, separated in needle-shaped crystals of muriat of lead.

When this precipitate had been separated from the alkaline solution, which before was saturated with only half the quantity of muriatic acid required, I combined that fluid with an additional portion of the same acid to its complete saturation. It became again turbid, but only moderately so. Upon this, a white precipitate accumulated, like starch, subsiding in cold water; which, carefullyedulcorated and dried, was examined in the same manner as the crystalline precipitate mentioned before, (4). Its habitudes were perfectly the same; except that it would not dissolve

M m 4

alone



alone in water, but formed a clear solution, only when a few drops of muriatic acid had been added.

The fluid was now concentrated by evaporation; after which the oxyd of molybdena, still contained in it, fell down as a fine, *heavy, yellow powder*; which, after proper lixiviation and drying, exhibited a beautiful, saturated lemon-colour.

6.) The white oxyd of lead, which remained upon the paper on filtering the softened mass, produced by the fusion of the ore with pot-ash (4), was found contaminated with a portion of siliceous earth. When treated upon charcoal, it did not entirely melt into a metallic button; but part of it was converted into a clear, bright, yellow globule of glass of lead (vitreous oxyd): for the admixed siliceous earth prevented the reduction of the whole portion of lead; in the same manner, as is the case when it is attempted to reduce upon charcoal a glass of lead, that has been made of three parts of oxyded lead and one of flux. For this reason, I dissolved the above-mentioned oxyd of lead in dilute nitric acid, separated the siliceous earth by filtration, and precipitated the metal from the solution, by means of sulphuric acid, in the character of sulphated lead.

7.) I likewise examined the actions of some of the acids upon this *Carinthian lead-ore*.—One drachm of it was digested with a copious quantity of nitric acid; which dissolved the greatest part, but not the whole of it. In the solution were observed white, loose flocculi dispersed, which dried upon the filtering paper in the form of a membrane, and became tarnished of a blue by exposure to daylight. This substance had much resemblance to the molybdic oxyd, obtained from molybdena in the humid way, by repeatedly distilling nitric acid from it. The filtered nitric solu-



solution contained, besides the portion of lead, a considerable quantity of molybdic oxyd. Sulphuric acid precipitated the lead from it; and Prussian alkali afterwards threw down the molybdena in loose, brown, red particles.

8.) *One drachm* of this yellow-lead ore, previously purified, afforded a clear solution, by digestion with muriatic acid. The solution went on gradually, and was nearly complete and colourless; but it soon deposited white crystals of muriated lead. Only a slight portion of flint was left behind, which I separated. While I was concentrating the fluid, the saline crust settling on the sides of the evaporating dish became tarnished of a fine blue; which as often disappeared as the crust was re-dissolved in the fluid, on gentle agitation. When the concentrated fluid had been decanted from the muriat of lead, which still subsided, it assumed a beautiful deep-blue, but lost that colour again by dilution with water. When afterwards saturated with potash, it dropped a white oxyd of molybdena.

9.) *Oxyd of lead*, and *oxyd of molybdena*, therefore, are the constituent parts of the *yellow lead-ore* from *Bleiberg*, in *Carinthia*. This combination is remarkable, as it is the first instance of the kind; since molybdena has not yet occurred any where, except in its proper ore (*Wasserbley*). From the foregoing experiments there also result some other observations, by which the knowledge of the chemical properties of that metallic substance (*molybdena*) is greatly enlarged. To these belongs its external form, as it occurs partly in the crystalline state, partly as a white, and partly as a lemon yellow oxyd. In the *first* state, it is soluble in simple water, as well as in acids; in the *second*, a small addition of muriatic acid promotes its solution in water; but in the third, or that of a yellow oxyd, it refuses to dissolve both in water and in acids. The cause of this



difference consists in this, that in the two first cases it has been neutralized with the portion of alkali that remained combined with it; whereas, in the last case, that is, in the form of a yellow earth, it is more in the state of a mere metallic oxyd.

10.) This appearance of the molybdic oxyd with a yellow colour, has probably been the reason for considering the substance, by which this yellow lead-ore is mineralized, as tungstic acid.

However, the blow-pipe alone is sufficient to distinguish these two metallic substances from each other; for, the yellow *molybdic oxyd* loses its colour at the first contact with the point of the flame, and is rendered *olive-green*; it also immediately runs into a small globule, or drop, which is very soon absorbed by the charcoal; and, lastly, when fused with a neutral phosphat, it tinges the button which thence arises of a *green* colour.

The *yellow oxyd of tungsten*, on the contrary, exchanges, by ignition, its yellow colour for a *blue* or *black*, at the same time that it remains upon the charcoal as perfectly infusible; and when fluxed with phosphoric salt, it gives a *sky-blue* colour to the saline globule.

## SECOND SECTION.

HAVING thus obtained, by means of the experiments here explained, the knowledge of the *constituent* parts of the *yellow lead-ore* from *Carinthia*, I had yet to discover their *proportions* to each other. This I accomplished in the following way.

a) *A hundred* grains of the crystals above described were carefully freed, in the manner before mentioned, from the ad-



adhering calcareous earth and ochre of iron, and then finely pulverized. They were then dissolved in muriatic acid, assisted by heat, alternately affusing upon them the acid, and a large quantity of water. In this instance a trace of siliceous earth, though scarcely discernible, appeared.

b) The greatest part of muriat of lead, generated in the process, was deposited in fine needles, even before the solution had completely grown cold. The super-natant clear fluid was then poured off, reduced to a smaller volume by evaporation, and freed from the muriated lead, which still separated. The muriated metal, collected with care, and briskly desiccated, weighed  $74\frac{1}{2}$  grains. By dissolving it in hot water, and steeping into the solution a polished piece of iron, the lead precipitated upon this last in fine lamellæ, and in the metallic state.

c) But in order to find more accurately what proportion this muriated lead might bear to pure oxyd of lead, I made the following experiment.

*Two hundred* grains of lead, cut into shreds, were dissolved in 300 grains of nitric acid, diluted with 10 ounces of water, and, with the assistance of digestion, in a boiling heat. The solution was then divided into two parts.

a) Into one half I dropped muriatic acid, as long as it produced any turbidness; evaporating afterwards the mixture to the most perfect dryness of the residue. The muriat of lead here produced weighed 133 grains.

β) From the second half of the nitric solution I precipitated the oxyd of lead by dissolved caustic potash. This oxyd, whenedulcorated and briskly dried till it began to turn yellowish, amounted to 115 grains.

540 LXIII. *Examination of the yellow Lead-ore, &c.*

From this it followed that those  $74\frac{1}{2}$  grains of muriated lead, obtained from 100 grains of the yellow molybdat of lead (*b*), are equal to 64,42 grains of pure oxyd of lead.

*d*) The concentrated muriatic solution of molybdena, which had a blue colour, was mixed with nitric acid, and lodged in a sand-bath for farther evaporation: Being thus circumstanced, it was again divested of its blue colour, and a yellow oxyd of molybdena separated. But when the evaporation had been carried on to complete dryness, I collected and weighed the remaining lemon-yellow oxyd of molybdena; and found it amount to  $34\frac{1}{4}$  grains.

Wherefore, *one hundred parts of the purest crystals of the yellow lead-ore, from Carinthia, contain:*

|                             |       |
|-----------------------------|-------|
| Oxyd of lead . . . . .      | 64,42 |
| Oxyd of molybdena . . . . . | 34,25 |
|                             | <hr/> |
|                             | 98,67 |



## LXIV.

## CHEMICAL EXAMINATION

OF THE

## SULPHURET OF COPPER,

*(Vitreous Copper-ore. Kupferglanzerz)**From SIBERIA.*

AMONG the copper-ores, the first place belongs to the grey, or *vitreous Copper-ore*, it being the richest in copper, and containing, besides its mineralizer, which is sulphur, the fewest foreign admixtures. Its purer varieties possess a degree of softness, so that they admit of being in some manner cut with the knife; and on the recent cut they resemble metallic lead in colour and lustre.

This ore usually occurs in compact masses; it is seldom crystallized. Of this latter sort I possess some from *Poldice* and *Dolcoath*, in *Cornwall*, in *druses* (groups of regular crystals) of minute white-grey, resplendent, tetrahedral, truncated pyramids.

For the subject of my enquiry, I took the massive, compact, moderately-soft vitreous copper-ore, from the mine *Gumeschfskoi*, on the river *Turja*, in the district of *Catharineburg*; where it is found in considerable large masses, which, in the *partings*, are invested with azure copper-ore, and fibrous malachites. It was freed from these previously to its being subjected to the following experiments.

A.

## A.

a) Upon *two hundred* grains of the ore, coarsely powdered, moderately strong nitric acid was affused, which attacked and dissolved them with frothing and extrication of red vapours. The solution was clear, and the sulphur alone in the ore was left behind, floating in the fluid, in grey, loose, flocculi, without any other residue; which indicated that no antimony was present. The sulphur collected on the filter was heated in a small crucible to inflammation, and it burned with its peculiar odour, without any trace of arsenic; yet leaving a slight portion of oxyded iron and siliceous earth.

b) The solution, which had a pure blue colour, was treated first with muriat, and then with sulphat of soda. But none of these, nor any other salt, rendered it turbid, or produced any other alteration; by which it appears, that this ore contains neither *silver* nor *lead*.

## B.

a) To determine, with proper accuracy, the proportion of the constituent parts, I repeated the examination in the following manner. *Two hundred* grains of the powdered ore were combined and heated with muriatic acid, to the degree of boiling. But as this acid alone manifested no action on it, I added nitric acid gradually, by drops; which exerted a strong attack in each instance. When the solution of the ore had been accomplished, I separated the fluid from the sulphur floating on the surface; and digested this last once more with a fresh quantity of muriatic acid, dropping into it some nitric acid; after which I collected it upon the filter. This sulphur, washed and desiccated, weighed  $38\frac{1}{2}$  grains, out of which, after its combustion,  $1\frac{1}{2}$  grain



grain of *siliceous earth* remained ; so that the true amount of *sulphur* was 37 grains.

b) The solution exhibited a glass-green colour. I divided it into two parts. Into one half polished iron was immersed ; upon which the *copper* precipitated of a dendritical form, and pure metallic brilliance. It weighed  $78\frac{1}{2}$  grains, when washed, and immediately deficcated in a moderate temperature.

c) In order to ascertain the proportion of iron contained in the ore, I combined the other half of the solution with caustic ammoniac added to excess of saturation. The precipitated iron remained behind, in the form of a subtle brown mud, which, collected on the filter, deficcated and ignited, weighed three grains. But as the iron is contained in the mixture of the ore, not in this calciform state, but in the reguline, which last is to the first in the proportion of 3 to 4, these 3 grains of oxyded iron give  $2\frac{1}{2}$  of *metallic iron* to be added in the computation.

Therefore, *hundred parts* of the *Siberian vitreous copper-ore* consist of :

|         |           |      |       |       |
|---------|-----------|------|-------|-------|
| Copper  | . . . . . | B b) | . . . | 78,50 |
| Iron    | . . . . . | c)   | . . . | 2,25  |
| Sulphur | . . . . . | a)   | . . . | 18,50 |
| Silex   | . . . . . | a)   | . . . | 0,75  |

---

100

### C.

Copper-ores eminently belong to those kinds, the component principles of which are but imperfectly determined by analysis *in the dry way*. The reason of this is, partly, that

that the alkaline salts employed for the reduction, exert, during fusion, as well as in the humid way, a very strong solvent power on copper.

But although the reducing flux, composed of glass, borax, and charcoal-dust, recommended by *Gellert*, *Tillet*, and others, instead of alkalis, is reckoned one of the best; yet I have always found the common *black-flux*, if employed in the following manner, the most effectual.

Two *docimaestic centners* (each of 100 parts, considered for as many pounds), of the triturated ore were mixed with half a centner (or 50 parts), of charcoal-dust, and properly roasted until all the coal was consumed\*. I then blended it with  $\frac{1}{2}$  centner of colophony and 6 centners of the black flux, covering the mass in the assay-crucible with common salt, and exposing it to a forge heat. After the coals were completely red, the blowing of the bellows was kept up for 20 minutes. The fusion being accomplished, I found, under a well-fluxed scoria, 138 parts of a fine red, or *refined copper*; which is 69 *per cent*.

However regularly this assay in the *dry way* was performed, yet it produced  $9\frac{1}{2}$  *per cent*. less than the true proportion of the copper in the ore amounts to. The *humid way*, therefore, is, in every respect, the most certain to discover the true quantity of copper in any ore.

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\* The roasted-ore weighed 210 pounds.



## LXV.

## CHEMICAL EXAMINATION

OF THE

## VARIEGATED COPPER-ORE.

*(Bunt-kupfererz. Purple Copper-Ore, by Kirwan.)*

THE *variegated Copper-ore* is distinguished in its external appearance from the *vitreous*, to which it is the nearest a-kin, by its variegated colours, resembling those of tarnished steel; and, with regard to its constituent parts, it differs from it in containing less copper, but, on the contrary, more iron.

## FIRST SECTION.

*Variegated Copper-Ore from Hitterdahl.*

THE variegated copper-ore occurring at *Hitterdahl*, in *Norway*, in lumpy masses, exhibits, on its recent fracture, a mixture of colours of light-blue, tin-white, and copper-red; which, however, by exposure to air, gradually change into a more uniform steel-blue.

## A.

One hundred grains of the pulverized ore were subjected to gentle digestion with nitric acid, whose action upon it was but moderate. From the residue, the sulphur was driven out by combustion. This residue, when a second time digested with nitric acid, dissolved in it, leaving only a slight portion of a red oxyd of iron. On examining the

N N

solution,

solution, first by common salt, and then by Glauber-salt, it continued limpid and unchanged.

## B.

a) Upon *two hundred* grains of the powdered ore muriatic acid was affused, the mixture heated, and then combined in small portions with nitric acid. The solution, which was thus performed, had a brown colour while concentrated; but as soon as it was diluted with water, it acquired a green. The remaining sulphur was grey, tenacious, and spongy, and weighed 72 grains when dry. By slow combustion it left 35 grains, of which, after extraction by muriatic acid, five grains still remained behind. These lost one grain more of sulphur by burning, and the remaining four grains dissolved entirely in muriatic acid. Whence the quantity of *sulphur* amounted to 38 grains.

b) The muriatic solution was divided into *two* equal parts; and the *copper* was precipitated from one of them by means of iron. It amounted to  $69\frac{1}{2}$  grains.

c) The other half was super-saturated with caustic ammoniac, and the oxyd of iron which fell down was collected. This, when moistened with linseed-oil, and exposed to a low red-heat, weighed 10 grains; which are equal to  $7\frac{1}{2}$  grains of *metallic*, or *reguline iron*.

Thus, in *one hundred* parts of this *variegated copper-ore* from *Norway* were found:

|                |             |       |
|----------------|-------------|-------|
| Copper . . .   | B. b) . . . | 69,50 |
| Sulphur . . .  | a) : . . .  | 19    |
| Iron . . . .   | c) . . . .  | 7,50  |
| Oxygen . . . . | . . . . .   | 4     |
|                |             | <hr/> |
|                |             | 100   |

By



In supplying the deficiency in the sum of weights of the copper, iron, and sulphur, from the hundred, by putting *oxygen* in the account, I mean to characterize this last as a constant constituent part of the variegated copper-ore, producing in it those variegated colours: in the same manner, as in steel, in copper-pyrites, and other metallic substances, the beginning of their oxydation is indicated by a similar diversity of colours.

In the last mentioned substances, however, the changeable colours are only owing to external causes; for which reason, they present themselves only on the surface, when long exposed to air. On the contrary, the variegated copper-ore is penetrated throughout its whole mass by the oxydating principle. This corresponds with the deficiency of weight to make up the sum of the fixed constituent parts of the ore here analysed; whereas no such loss is observable in the vitreous copper-ore, treated and decomposed by the same method. It is on this account also, that the action of the nitric acid is less strong, and the disengagement of nitrous gas is less copious, in the variegated than in the vitreous copper-ore.

## SECOND SECTION.

### *Variegated Copper-Ore from Rudelsdorf.*

THE native place of this variety of variegated copper-ore is the mine *Friederike Juliane*, at *Rudelsdorf*, in *Silesia*, in which a rich vein has lately been opened, of beautiful native silver, imbedded in ponderous spar, and accompanied by pyramidal red silver-ore, along with crystallized white cobalt-ore (*Glanzkobalt*), that has raised the ardent wishes of the proprietors for its continuance.

## A.

*Two hundred* grains of the powdered ore, having been twice extracted by means of nitric acid, left behind their sulphureous ingredient, together with a quantity of red oxyd of iron. The solution was filtered, and tried by proper reagents for silver, lead, zinc, arsenic, and the like, and it afforded no indication of these, but only of copper and iron.

## B.

a) *Two hundred* grains of this ore, in pure pieces, freed from interspersed quartz, were triturated, and treated with muriatic acid, to which a little nitric acid was afterwards added, and the extraction continued in a moderate warmth. The colour of the filtered solution was a celadon, or blueish green, with a shade of grey. The residue, porous like sponge, weighed at first 88 grains; but only 56 grains, after its sulphur had been gently burned off. These, digested in a low heat with muriatic acid, soon dissolved, forming a brown fluid, and left six grains more of sulphur behind. Hence, the *sulphur* contained in those 200 grains amounted to 38 grains.

b) These solutions were mixed together, and divided into *two equal parts*. From one half I precipitated the *copper* in due manner by means of a polished piece of iron, and obtained 58 grains.

c) The other half was treated with caustic ammoniac, until the oxyd of copper, precipitated in the beginning, again dissolved. The oxyd of iron, thus obtained, when collected on the filter, washed and desiccated, was moistened with linseed-oil, and ignited in a covered crucible. It



weighed 24 grains. Hence, as, upon an average, four parts of oxyded iron, attractible by the magnet, are to be estimated as equal to three parts of reguline iron, I reckon 18 grains of *metallic iron*, instead of these 24 grains.

Since, for the same reason as in the foregoing analysis, the loss of weight in the sum of the fixed constituent parts must be taken for the *oxygen* combined with the ore, and which escaped in the process; the constituent parts of the *Silesian variegated copper-ore*, and their proportions in the *hundred*, will be :

|         |             |          |
|---------|-------------|----------|
| Copper  | . . . B. b) | . . . 58 |
| Iron    | . . . . c)  | . . . 18 |
| Sulphur | . . . a)    | . . . 19 |
| Oxygen  | . . . . .   | . . . 5  |

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C.

With a view of making an *assay in the dry way*, I roasted two docimaetic centners with half a centner of powdered charcoal. The roasted ore, now weighing 206 lb. was then mixed with half a centner of colophony, and six centners of black flux. In this state it was put in a crucible, and covered with muriat of soda. When kept in fusion during 20 minutes before the nozzle of the bellows, it yielded a fine button, weighing 96 lbs. of red, or refined copper; which is 48 *per cent.* and hence, 10 lbs. short of what was obtained in the *humid way*, (B. b).

## LXVI.

## CHEMICAL EXAMINATION

OF THE

## SIBERIAN MALACHITES.

a) *ONE thousand* grains of compact, reniform *Malachites*, from the *Turjin* mines, on the *Ural*, were reduced to powder, and heated to complete redness in a small glass retort, connected with the pneumatic apparatus. Much carbonic acid gas was disengaged in this process, to the amount of 252 cubic inches, without reckoning that part which was absorbed by the water of the apparatus. This gas was entirely absorbed by lime water, at the same time that a proportionate quantity of carbonated or crude calcareous earth was produced. In the intermediate small receiver a moisture collected, weighing 78 grains, which, upon trial, proved to be pure water.

b) The pulverulent residue taken out of the retort appeared of a black colour, and weighed 716 grains. To serve for the following experiments, it was divided into four parts, at 179 grains each; and hence corresponding to 250 grains of the rough malachites.

1.) *One hundred and seventy-nine* grains of ignited malachites, combined with three times its quantity of black flux, were put into an assay-crucible, without lining it, and covered with *muriated soda*. In this situation it was committed to the fire of the blast-furnace, and when the coals had become red-hot without the action of the bellows, it was kept melting  
for



for the space of twenty minutes. After cooling, it was observed that, in the broken retort, the whole mixture, under the covering of common salt, had run into an uniform, compact, and opaque mass, of the bright red-colour of ordinary sealing-wax, and that no metallic button had been formed.

It follows from this, that there was not carbon enough present to take up entirely the oxygen of the metallic oxyd. Therefore the copper has, by means of this small remainder of oxygen still united with it, been brought into the state of red oxyd of copper; and, as such, it has diffused itself uniformly through the alkaline salt.

2.) *Hundred and seventy-nine grains of ignited malachites* were mingled with three times their quantity of *black-flux*, and 1-10th of *powdered charcoal*. When fused in this state, during 20 minutes, under a stratum of *common salt*, in an assay-crucible not lined in the inside, they afforded a button of reguline copper, which had run well together, and weighed  $136\frac{1}{2}$  grains.

3.) Another 179 grains of *ignited malachites*, mixed with *thrice* as many grains of *black-flux*, and one fifth part of their weight of *colophony*, and likewise fused for 20 minutes, under a cover of *muria* of soda, in a crucible not secured by lining, yielded a well-melted button of reguline copper, weighing 138 grains.

4.) The remaining 179 grains of *ignited malachites* were, like the preceding, melted during the time of 20 minutes, under a cover of *common salt*. But the assay-crucible had previously been lined with powdered charcoal, and the malachites mingled with an equal weight of *calcined borax*, with half its quantity of *white glass*, and 1-4th part of *colo-*

*phony*, or boiled turpentine. By this process I obtained, indeed, a well-fused button of reguline copper; but with a considerable loss, as it weighed only  $105\frac{1}{2}$  grains.

## B.

In order to discover more accurately the constituent parts of malachites, I performed the following experiments.

a) 100 grains of malachites, reduced to powder by trituration, were dissolved in nitric acid; which was effected without leaving any residue. The solution had a bright-blue-colour, and was saturated to excess with caustic ammoniac: but the precipitate produced was entirely, and without turbidness, re-dissolved by the excess of the alkali. This shewed that the malachites here examined was perfectly free from iron, and similar admixtures.

b) I combined *hundred* grains of triturated malachites with a sufficient quantity of sulphuric acid, previously diluted with five parts of water, and accurately weighed together with the vessel. After the malachites had been wholly dissolved, which was effected gradually, and with a moderately strong effervescence, the loss of weight, occasioned by the *carbonic acid gas* that was extricated, was found to consist of 18 grains.

c) *One hundred* grains of the same powdered malachites were ignited, at a moderate heat, in a covered crucible. The black residue had lost  $29\frac{1}{2}$  grains in weight. If from these be subtracted 18 grains for the carbonic acid, the remaining  $11\frac{1}{2}$  grains of loss will consist of *water*.

Another



d) And lastly, 100 grains, which had been dissolved in dilute sulphuric acid, and precipitated by zinc, yielded 58 grains of pure *copper*.

In consequence of these experiments, the *Siberian malachites* consists, in the *hundred*, of:

|                                |       |
|--------------------------------|-------|
| <i>Copper</i> . . . . .        | 58    |
| <i>Carbonic acid</i> . . . . . | 18    |
| <i>Oxygen</i> . . . . .        | 12,50 |
| <i>Water</i> . . . . .         | 11,50 |

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CHEMICAL EXAMINATION  
OF THE  
*BISMUTHIC SILVER-ORE,*

From *Schapbach*, in the *Black-forest*,  
In *Suabia*.

THE *Bismuthic Silver-ore*, which occurs in the mine *Friederich-Christians*, in the valley *Schapbach*, in the *Black-forest*, (*Schwarzwald*), and for the first acquaintance with which we are indebted to Mr. *Selb*\*, Master of the mines at *Wolfach*, has been described, as to its external characters, by *Widenmann*† and *Emmerling*‡. This mineral deserved a complete chemical inquiry so much the more, as even now several *Mineralogists* still seem to doubt of the existence of this peculiar species of ores.—For this reason, I publish here its analysis, which to perform I was enabled by Mr. *Selb*, sending me of this mineral the quantity necessary for the purpose.

Since this ore is very much concreted with the *grey quartz*, serving to it as a matrix; and since in most specimens it can be considered as only disseminated in the quartz, I have employed for its analysis merely such pieces as are the least mixed with quartz, and, at the same time, the most free from copper-pyrites and galena, which accompany this ore.

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\* *Chemische Annalen*, 1793. I. Band. Seite. 10.

† *Handbuch der Mineralogie*, Leipzig, 1794, page 716.

‡ *Lehrbuch der Mineralogie*, II. Theil. Gießen, 1796. Seite 203.



## A.

*Examination in the dry way.*

a) If bismuthic silver-ore, in small fragments, be ignited upon charcoal before the blow-pipe, there soon transude metallic drops of easy fusion; which *eliquate*\* more perfectly on the addition of borax. The glass of borax acquires by them a yellow colour, resembling that of amber (*Succinum*), but mixed with white, and in some places also with a copper-red. The metallic button exhibits variegated colours, and continues long in fusion. It is brittle, and appears of a tin-white in the fracture.

b) When *three hundred grains* of this ore, previously triturated, had been exposed to a red-heat, in a small retort, lodged in sand, they afforded,—besides a slight quantity of aqueous moisture, no more than  $2\frac{1}{2}$  grains of sulphur; the pure yellow colour of which proved the total absence of arsenic. On the powder of the ore, which coalesced but moderately, some metallic drops were found incumbent. It was then roasted in an open test, until no trace of sulphureous smell could be observed. After this process, it had an ash-grey colour, appeared of a very loose texture, and weighed 313 grains.

On being combined with  $1\frac{1}{2}$  ounce of black flux, and reduced in an assaying-crucible, under a layer of culinary salt, it ran into a tin-white metallic button, which weighed 174 grains, would admit of being cut with a knife, and, though it had become malleable, yet was brittle, and fell asunder after some blows of the hammer.

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\* On the process of *eliquation*, in general, see *Gren's Principles of Chemistry*, Lond. 1800, vol. II. page 301.—Trand.



This metallic bead, when refined by cupellation, under the muffle, afforded a button of *pure reguline silver*, weighing  $33\frac{1}{2}$  grains.

## B.

*Examination in the humid way.*

a) Upon *three hundred* grains of this ore I poured three ounces of nitric acid, diluted with one ounce of water. A great part of it dissolved in this menstruum, even in the cold. The residue was afresh combined with one ounce of the same acid, weakened with half an ounce of water, and digested in a gentle heat. Both solutions, thus obtained, were filtered, mixed, and together evaporated to a smaller volume; during which process there separated from the fluid some crystalline grains, consisting of nitrat of lead.

b) The concentrated solution had a greenish colour.—When afterwards diluted with just as much of water as was requisite to re-dissolve that crystalline sediment, it was poured into a large quantity of water. This last immediately acquired a milky appearance, in a high degree, and deposited a white precipitate, which weighed  $44\frac{1}{2}$  grains, when collected, lixiviated, and dried in the air, and proved, on farther examination, to be *oxyd of bismuth*.

c) Into the liquor, that had been freed from this oxyd, and was entirely clear and colourless, I then dropped muriatic acid, as long as it was rendered turbid by it. The precipitate which then ensued, did not appear to be mere muriat of silver; for this reason, I digested it for some time with a moderately strong nitric acid. A considerable portion of it was thus re-dissolved, and left pure horn-silver behind; which, upon careful collection, and desiccation in a brisk heat, weighed 46 grains. Thus, the portion of pure *silver* is determined at  $34\frac{1}{2}$  grains.

d) The



d) The nitric acid, that had been affused upon the precipitate obtained by the muriatic (c), yielded, by dilution with much water, 32 grains more of oxyded bismuth; which, with the preceding  $44\frac{1}{2}$  (b), gave together  $76\frac{1}{2}$  grains.

In order to ascertain the proportion of reguline bismuth in this ore, I dissolved 100 grains of bismuth in nitric acid; and after having concentrated the solution by evaporation, I poured it into a large quantity of water. When of the precipitate, thus produced, nothing more would fall down, on adding more water, I collected it on the filter, washed it, and suffered it to dry perfectly in the air. It then weighed 88 grains. To the water, which had been separated from it, muriatic acid was added by drops; whereby a new precipitate ensued, weighing 35 grains, afteredulcoration and drying.

As, by the result of this comparative experiment, *one hundred grains of reguline bismuth* have, upon the whole, given 123 grains of *oxyded bismuth*; it follows, that the  $76\frac{1}{2}$  grains of bismuthic oxyd, mentioned at (d), and obtained from 300 grains of the bismuthic silver ore, contain  $62\frac{1}{2}$  grains of *metallic, or reguline bismuth*.

e) The remainder of the fluid was farther reduced by evaporation; and, in this process, muriat of lead separated from it in delicate, broad-striated crystals. This liquor was then combined with such a quantity of sulphuric acid, as was requisite to re-dissolve those crystals, and a second time evaporated to a consistence of pap. The precipitate, which thence ensued, was sulphat of lead, weighing 19 grains, when duly collected, washed, and dried.

f) What still remained of the solution, after its having been freed from the lead before contained in it, was saturated

rated with caustic ammoniac added in excess. In this way a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains; when, after previous desiccation, it had been moistened with linseed-oil, and well ignited.—For these we must reckon 10 grains of metallic iron.

g) The liquor, which had been super-saturated with ammoniac, and which, by its blue colour, shewed that it held copper in solution, was next saturated to excess with sulphuric acid. On immersing then a piece of polished iron into it, two grains of copper were deposited.

h) The grey residue of the ore, that was left behind by the nitric acid (a), weighed 178 grains. But when its sulphureous part had been deflagrated, in a crucible gently heated, it weighed only  $140\frac{1}{2}$  grains. This determines the portion of sulphur at  $37\frac{1}{2}$  grains.

i) These  $140\frac{1}{2}$  grains were digested with three ounces of muriatic acid, in a heat of ebullition; and this process was repeated once more with  $1\frac{1}{2}$  ounce of the same acid. These solutions, by means of evaporation, yielded till the end muriat of lead in tender spicular, and likewise in broad-striated crystals; which, when again dissolved in the requisite quantity of boiling water, then combined with sulphuric acid, and evaporated, yielded 89 grains of sulphated lead. Thus the whole quantity of this sulphat, including the 19 grains mentioned at (e), amounted to 108 grains; for which, according to comparative experiments, 76 grains of reguline lead must be put in the computation.

k) That portion of the ore examined, which still remained after all the constituent parts before mentioned have



*Bismuthic Silver-ore from Schapbach.* 559

been discovered, consisted merely of the *grey quarzose matrix*; the weight of which, in the ignited state, amounted to 70 grains.

Therefore, those *three hundred* grains of *bismuthic silver-ore*, mentioned above, were decomposed into:

|                    |       |
|--------------------|-------|
| Lead . . . i)      | 76    |
| Bismuth . . . d)   | 62,20 |
| Silver . . . e)    | 34,50 |
| Iron . . . f)      | 10    |
| Copper . . . g)    | 2     |
| Sulphur . . . h)   | 37,50 |
| Quarzose matrix k) | 70    |

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292,20 grains

It follows from this statement, that, exclusively of the *quarzose gangue*, the constituent parts of the *bismuthic silver-ore* alone consist, in the *hundred*, of:

|               |       |
|---------------|-------|
| Lead . . . :  | 33    |
| Bismuth . . . | 27    |
| Silver . . .  | 15    |
| Iron . . .    | 4,30  |
| Copper . . .  | 0,90  |
| Sulphur . . . | 16,30 |

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96,50

## LXVIII.

## CHEMICAL EXAMINATION

OF THE

## ANTIMONIATED SILVER,

*from Wolfach, in Suabia.*

ANOTHER fossil, which is found only in the mines worked in the principality of *Fürstenberg*, is the *Antimoni-ated Silver*. It occurs there in the pit, called *Wenzelsgrube*, near *Alt-Wolfach*; and its external characters have also been described by *Widenmann*\* and *Emmerling*†, in their elementary Introductions to Mineralogy.

It has already been proved by *Bergmann*‡, but more circumstantially by *Selb*§, that this mineral is a compound of native silver and reguline antimony.

*Selb* employed in his experiments that variety of antimoniated silver, which, in former times, has occurred more frequently in coarse-granular detached pieces; and he found its proportion of silver to amount from 70 to 75 in the hundred. But the fine-granular variety, which is now dug, is considerably more rich in silver.

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\* *Handbuch der Mineralogie*, 1794, page 684.

† *Lehrbuch der Mineralogie*, II. Theil. page 162.

‡ *Opusc. Phys. et Chem.* vol. II. page 416.

§ *Magazin für die Bergbaukunde*, von *Lempe*, III. Theil. page 5.



FIRST SECTION.

*Antimoniated Silver in fine Grains.*

A.

*Examination in the dry Way.*

a) A SMALL piece of antimoniated silver, when tried upon charcoal, with the assistance of the blow-pipe, soon entered into fusion. The antimonial part volatilized in its usual vaporous state, and left the button of silver entirely pure behind. Neither of sulphur nor of arsenic any trace appeared.

b) Twenty-five grains, mixed with four times their weight of lead, and subjected to cupellation, yielded a button of pure silver, weighing 21 grains.

B.

*Examination in the humid way.*

a) Nitric acid was poured upon *hundred* grains of antimoniated silver, freed from calcareous spar adhering to it, and pulverized as much as its toughness would admit. The acid shewed no considerable action in the cold. Therefore I subjected the whole to a digesting heat, in which I kept it, until nitric acid, added afresh, would not farther attack this powder. Upon this I diluted the mixture with water, separated the residue, and precipitated the silver from the colourless solution, by means of copper. The *silver*, thus obtained, amounted to  $83\frac{1}{2}$  grains, when lixiviated and dried in a warm temperature.

x o

b) The

b) The residue exhibited a reddish-white colour, after being washed and defecated in the air, and weighed 25 grains. It soon dissolved in the muriatic acid, with which it was digested; leaving behind it a small portion of muriated silver, which, upon reduction, by means of soda, in the small spoon, still gave  $\frac{1}{2}$  grain of silver.

c) I poured the muriatic solution into a large quantity of water. By this management it was decomposed, and let fall a white, tender precipitate; which, dried in a gentle heat, weighed  $20\frac{1}{2}$  grains. This precipitate, upon trial, proved to be an oxyd of antimony, perfectly resembling *powder of algaroth* (oxyd of antimony by the muriatic acid). One part of it I re-dissolved in muriatic acid; and the solution, when poured into water previously impregnated with sulphuret of ammoniac, yielded golden sulphur of antimony, of a pure orange colour. The remaining part gave, by reduction with tartar, a metallic button; which, on being blown off with the bellows, entirely evaporated, without leaving any residue.

Therefore, since, by the result of other comparative experiments\*, 16 grains of reguline antimony may be reckoned for those  $20\frac{1}{2}$  grains of the metallic oxyd (c), the constituent parts of the *fine-granular* variety of the *antimoniated silver* are in the following proportion :

|                           |    |
|---------------------------|----|
| Silver . . . . .          | 84 |
| Reguline antimony . . . . | 16 |

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100

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\* See page 130 of this work.



of the antimoniated Silver from Wolfach. 563

SECOND SECTION.

*Antimoniated Silver in coarse Grains.*

ONE hundred grains of the coarse-granular variety of antimoniated silver, when decomposed in the same manner as the preceding, yielded :

|                           |     |
|---------------------------|-----|
| Silver . . . . .          | 76  |
| Reguline antimony . . . . | 24  |
| <hr/>                     |     |
|                           | 100 |

## LXIX.

## CHEMICAL EXAMINATION

## OF THE

## CRYSTALLIZED, BRIGHT, WHITE

## COBALT-ORE,

(Glanzkobalt),

From TUNABERG, in Sweden.

THE crystals of the *Bright, White Cobalt-ore*, which occurs at *Tunaberg*, in *Südermannland*, together with the copper-pyrites (*yellow copper-ore*), are distinguished by the stronger metallic lustre of their external surfaces, which renders them less liable to decay, as well as by their size, of a rather uncommon magnitude\*.

The colour of their surface and recent fracture is a tin-white passing into the grey; and the form of these crystals consists, for the most part, in variations of the cube, with unequally truncated edges, and striated lateral facets. The *striae*, or small channels of each surface, are parallel to those of the opposite one, but perpendicular to those of the ad-

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\* One of these crystals, extremely beautiful and large, and detached from others, is in the possession of M. *Mierotto*, Counsellor in the Ecclesiastical Department at Berlin; whose collection of minerals is so highly instructive with regard to the *Geognosy* of the countries situated on the *Baltic sea*. This crystal is  $1\frac{1}{2}$  inch long, of the same height, one inch broad, and weighs  $4\frac{1}{2}$  ounces.



joining side. This remarkable direction of the *striae* has, till now, been found only in this cobaltic ore, and in some cubes of sulphur-pyrites, striated in the same manner. The fracture of these crystals is uneven, and exhibits a foliated texture.

I. *Experiments in the humid way.*

A.

One hundred grains of this cobalt-ore were digested with nitro-muriatic acid, in a boiling heat. The metal dissolved but slowly, and in a small quantity. As long as the solution was hot, it appeared of a dark emerald-green; but, upon cooling, it turned reddish-brown. No arsenic would deposit from it. Hence, the above menstruum did not seem likely to effect the decomposition which I intended of the cobaltic ore.

B.

a) Hundred grains of rough white cobalt-ore, when gently digested with nitric acid, dissolved in it gradually; however, leaving behind them  $16\frac{1}{2}$  grains of small, white-grey, resplendent globules, which consisted of arsenic, together with a little sulphur. By boiling with water, this arsenical ingredient was dissolved, and there remained  $1\frac{1}{2}$  grain behind; of which  $\frac{1}{2}$  grain of sulphur deflagrated on a small hot test. The remaining 1 grain was oxyd of cobalt.

b) The brownish-red nitric solution was evaporated to a part, on a sand bath. In this process there still separated an oxyd of arsenic, in the form of a white crystalline incrustation; which, collected after cooling, and by degrees lixiviated with a little water, weighed 30 grains after desiccation.

tion. It again entirely dissolved in the water with which it was boiled.

c) Both the solutions of the arsenical oxyd in water shewed exactly the same appearances which are exhibited by any other aqueous solution of arsenic. By combination with lime-water, they yielded *arseniat of lime*; with sulphuret of ammoniac they produced *yellow sulphuret of arsenic* (orpiment), and the *green pigment of Scheele* with ammoniacal oxyd of copper.

d) When the nitric solution of cobalt would no longer deposit any arsenic, I diluted it with water, and precipitated, by means of vegetable alkali, the oxyded cobalt; which, at first, had a peach-flower colour, and, towards the end, that of lilac. On dissolving this last, precipitated in muriatic acid, and diluting the solution with water, the liquor acquired a rose-red colour, and afforded the well-known sympathetic ink prepared from cobalt.

Therefore, the constituent parts of the *crystallized, white cobalt-ore*, separately produced in this analysis, consist, in the *hundred*, besides the portion of cobalt itself, of 45 grains of arsenical oxyd, and  $\frac{1}{2}$  grain of sulphur: but of any portion of iron no trace appeared.

However, as I had reason to suppose that the ingredient proportion of arsenic here stated might, perhaps, not be the true one, I endeavoured to ascertain it more accurately in the dry way.

## II. *Experiments in the dry Way.*

### A.

a) *Four hundred* grains of white cobalt-ore, coarsely powdered, were heated to redness in a small glass retort, connected



necked with a receiver, and kept in the state of ignition for some time. After cooling there appeared in the neck of the retort no more than *one* grain of sublimed arsenic, together with a slight trace of sulphur.

b) The contents of the retort were then introduced into 2 small open matrasss, and once more strongly ignited; but no sublimation ensued.

c) Upon this, I mixed the cobalt with 1-4th part of its weight of powdered charcoal, and calcined it in a shallow open pot. At this instant the arsenic escaped in vapours; but slowly, and it coated metallic substances, that were held over the pot, with a thick white crust. The smell of this vapour resembled that of garlic, only in very moderate degree; and it ceased to be emitted after the roasting had been continued for two hours.

But, by this calcination, the cobalt was not yet entirely deprived of all portion of arsenic; for, when it had been dissolved in nitric acid, and the solution concentrated by evaporation, there was still some arsenic deposited.

## B.

a) For this reason, another *two hundred* grains of rough, white, cobalt-ore, previously triturated, were, in the first instance, mixed with 100 grains of charcoal-dust, and calcined. This roasting was twice repeated, mixing the ore each time with 50 grains of powdered charcoal; after which it no longer emitted any trace of exhaling arsenic. The cobaltic oxyd, which now, to appearance, had been entirely freed from arsenic, weighed 104 grains, and exhibited a black colour.

b) These 104 grains were mingled with carbonat of potash and crude tartar, of each three drachms. The mixture, when introduced into a small crucible, and covered with muriat of soda, was kept in the fire, before the nozzle of the bellows, during 20 minutes. The cobalt, thus reduced to the reguline state, was found to weigh 75 grains. Its external surface had a finely knit, or interwoven appearance. But when I endeavoured to break it by the hammer, it proved to be hard, and somewhat tenacious. Its internal surface was partly porous; partly it exhibited a rough fracture, passing into the *hackly*, that is, presenting sharp points to the feel.

c) After these 75 grains of metallic cobalt had been pounded, they were roasted, in a brisk fire, for two hours; upon which the calcined cobalt appeared again in the character of a black oxyd, with an increase of weight of 18 per cent.

Since it may be presumed, with probability, that this cobaltic oxyd, which has been re-produced from the reguline cobalt revived at (b), contains oxygen in the same proportion with the oxyd prepared by roasting the rough cobalt ore; and, as consequently, those 104 grains (a) of oxyded cobalt have contained 88 grains of pure reguline cobalt; it follows, that the constituent parts of this *white cobalt-ore*, from *Tunaberg*, are, in the hundred:

|                        |       |
|------------------------|-------|
| Reguline cobalt . . .  | 44    |
| Sulphur . . . . .      | 0,50  |
| Reguline arsenic . . . | 55,50 |
|                        | <hr/> |
|                        | 100   |



## CHEMICAL EXAMINATION

OF THE

## COBALTIC ORE OF MANGANESE,

FROM RENGERSDORF, in *Lusatia*.

THE fossil that was the object of the present enquiry occurs near *Rengersdorf*, in *Upper-Lusatia*, in a stratum of quartz, which, on the *Heideberg*, comes up to the day. It has, till now, been considered as a *black hæmatitic iron-stone*\*, until the late Professor *Leske* has introduced it as a *black cobalt-ore*†. However, as he declared to entertain a wish that this classification, which he founded partly on the external characters of this fossil, partly on some previous experiments made with it‡, might be farther examined by a chemical analysis, it was by this declaration that M. *Westrumb* was induced to undertake this task.

From the appearances which this celebrated chemist observed on experimenting with this fossil, it resulted, that it contained *manganese*: but, on the other hand, he denied it to contain a portion of *cobalt*§, which, however, *Leske* had suspected in it.

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\* Schwarzer, Glasköpfiger Eisenstein.

† Schwarzer Erzkobalt.

‡ *Reise durch Sachsen* von N. G. *Leske*. Leipzig, 1785. Page 230—230.

§ *Kleine Phys. Chem. Abhandlungen*, von *Westrumb*, 2ter Band, 2 Heft, 1788, page 183.

My examination of this mineral substance, of which I have received a stock from M. de Gersdorf, the worthy proprietor of the estates of *Messersdorf* and *Rengersdorf*, where it is found, has convinced me that, besides manganese, it indeed contains cobalt: but it has, at the same time, shewn, that the presence of cobalt is hid by the predominant portion of manganese combined with it, or, at least, rendered unobservable on the first inspection of the fossil.

## A.

a) The rough fossil, when treated upon charcoal, under a stream of air, continued for some time from the blow-pipe, fuses into an apake, blueish scoria.

b) Phosphoric salt produces with it, by the same treatment, a crimson-red vitreous globule.

c) Borat of soda is tinged by it of a dark hyacinthine-red; which colour, on adding a slight portion of arseniated soda, passes into a pale blue.

d) One hundred grains of this fossil were first calcined in a gentle heat, and afterwards ignited during half an hour. The fossil lost thereby 17 grains in weight, and its blackish colour was changed to a dark ash-grey. During this process of roasting, there could not be observed either smoke or smell; and the loss consisted merely of *aqueous particles*.

## B.

a) Five hundred grains of this fossil, previously comminuted in the mortar, were digested with a moderately strong  
mu-



muriatic acid. There escaped vapours of oxygenated muriatic acid. By continuing the digestion at the degree of ebullition, the mixture lost its brown colour, and the fluid became green, leaving a white earthy residue behind. But, on diluting the solution with water, its green colour disappeared, and the filtered liquor acquired a weak brownish-red. The residue, separated by filtration, weighed 206 grains, after ignition.

b) I then reduced the volume of the muriatic solution by evaporating it; during which process *siliceous earth* was deposited, weighing 10 grains, when collected on the filter and ignited. After this I saturated the solution with dissolved caustic pot-ash, added in excess, kept the mixture for some time in digestion, and filtered it. A muddy residue remained on the paper, the dirty light-brown colour of which rapidly turned black on exposure to air.

c) The fluid separated from this residue was neutralized with muriatic acid, and then combined with carbonat of pot-ash. It deposited *aluminous earth*, the quantity of which, after ignition, amounted to 12 grains.

d) The above black residue (b) was again dissolved in muriatic acid, and thrown down by mild vegetable alkali. The precipitate appeared of a pale-reddish colour. Whenedulcorated and dried, I subjected it to strong red-heat, for one hour, in a calcining pot. It returned from the fire of a greyish-brown hue, and weighed 178 grains.

e) I subjected these 178 grains, for some time, to digestion, in a boiling heat, with a moderately strong nitric acid, diluting afterwards the solution with water, and filtering it. There remained a tender, black residue behind, which, uponedulcoration, drying, and ignition, weighed 80 grains,



grains, and was *oxyd of manganese*. In order to try it for iron, I again digested it with nitric acid; in which, on the addition of a little sugar, it immediately dissolved, without leaving iron, or any other residue. When again precipitated by means of carbonated pot-ash, it fell down as a carbonated oxyd of manganese, of a white colour, verging into the isabella yellow.

f) Hence the nitric solution still contained 98 grains of the mentioned 178; but from the first there must be subtracted *one* grain for copper, discovered in the sequel. By mild vegetable alkali, this re-dissolved portion was again precipitated, of a pale colour of peach-flower; and this precipitate, as the following examinations of it have shewn, consisted of an accurate mixture of *oxyds of cobalt and manganese*.

g) The 206 grains, which remained on dissolving the crude fossil (a), were mixed with twice their weight of carbonated pot-ash, and moderately ignited during two hours; after which they were covered with water, super-saturated with muriatic acid, and evaporated to a gelatinous consistence: and when the *siliceous earth* had been separated, washed, and ignited, it was found to weigh 114 grains.

h) I then neutralized the remaining muriatic liquor with carbonat of pot-ash, and combined it afterwards with oxalat of pot-ash: but by this neither any precipitation nor turbidness has been effected. It was then combined with caustic ammoniac, which threw down *aluminous earth*, the quantity of which, after ignition, consisted of 90 grains. The still remaining portion of the fluid continued clear on the addition of carbonated soda.

i) With a design to ascertain the proportion of copper which enters into this fossil, and the presence of which has  
al-



already been observed in the previous experiments, I affused sulphuric acid upon 500 grains of the rough fossil, evaporated the fluid on a sand-bath, softened the inspissated mass with water, and immersed, after filtration, a polished plate of iron into the clear solution, which had acquired a pale rose colour. The plate of iron became gradually incrustated with a cupreous pellicle; which, when carefully collected, weighed no more than  $\frac{1}{2}$  grain; and thus one grain of *oxyd of copper* must be put in the computation.

Therefore, the *five hundred* grains of the fossil here examined have been decomposed into:

|                                    |       |           |           |
|------------------------------------|-------|-----------|-----------|
| <i>Oxyd of cobalt</i> , mixed with |       |           |           |
| <i>oxyd of magnesia</i>            | B. f) | . . . . . | 97        |
| Mere <i>oxyd of manganese</i>      | e)    | . . . . . | 80        |
| <i>Oxyd of copper</i>              | i)    | . . . . . | 1         |
| <i>Silex</i>                       | b)    | 10 }      | 124       |
| —                                  | g)    | 114 }     |           |
| <i>Alumine</i>                     | c)    | 12 }      | 102       |
| —                                  | b)    | 90 }      |           |
| <i>Water</i>                       | A. d) | . . . . . | 85        |
|                                    |       |           | <hr/> 489 |

C.

But, that the 97 grains mentioned at (B. f), and which were obtained in the carbonated state, have really consisted of a mixture of oxyded cobalt and manganese, has been proved by the following experiments; the phenomena of which, at the same time, were compared with those that are exhibited by the pure carbonated oxyd of manganese.

1. a) The colour of the above precipitate, in the carbonated state, is the pale peach-flower red, and changes, on ignition, into the light-brown.

b) The

b) The colour of the carbonated manganefian oxyd is white, inclining to the isabella-yellow ; and that of ignited oxyd of manganefe is black-brown.

2. a) If the ignited cobalto-manganefian precipitate be digested with nitric acid, in a boiling heat, it leaves behind it a residue in the form of a subtle, black powder. If then carbonated pot-ash be added to the filtered solution, which has a very pure, but dilute rose-red colour, the dissolved matter is thrown down by the alkali, of its former peach-flower red. The black residue, left unattacked by the nitric acid, when heated to redness, and digested in a heat of ebullition with a fresh portion of nitric acid, is redissolved for the greatest part ; and its dissolved portion is again precipitated, of a pale red colour, by mild pot-ash.

b) The ignited black-brown oxyd of manganefe, by itself alone, is insoluble in nitric acid ; the acid that is boiled with it continues colourless, and lets nothing fall down on being saturated with an alkali.

3. a) If the above compound precipitate of cobalt and manganefe be dissolved in muriatic acid, and abundantly supersaturated with carbonated ammoniac, the clear fluid which stands over the sediment acquires, after some time, a dilute colour, resembling that of the blossom of flax-weed.

b) The oxyd of manganefe, on the contrary, when dissolved in the same manner in muriatic acid, and precipitated by carbonat of ammoniac, added to excess of saturation, leaves the liquor standing over the sediment entirely colourless.

4. a) On adding the mentioned cobaltic precipitate of manganefe to a neutral phosphat, fused upon charcoal, the clear globule becomes tinged of a pure sapphire-blue colour, which



which continues unchanged by the outer, as well as by the inner flame of a candle, directed on it by the blow-pipe.

b) Oxyd of manganese, alone, produces with the phosphoric salt a globule, which is devoid of all colour when urged by the interior flame, but acquires an amethystine red by the heat of the exterior.

5. a.) The combination of borax with the cobalto-manganefian precipitate, upon the charcoal, before the blow-pipe, produces a glass globule of a dirty blueish colour, inclining to the blackish-grey. But as soon as a small quantity of arseniated soda is added, a pure sapphire-blue colour appears.

b) Oxyd of manganese imparts to borax, when vitrifying upon the coal, a dark amethystine, and sometimes a hyacinthine red colour. But the glass globule is immediately rendered colourless by the addition of arseniat of soda.

6. a) When the precipitate compounded of cobalt and manganese is dissolved in concentrated muriatic acid, the solution acquires a pale rose colour, and it becomes grass-green by heating. As the solution cools, its green colour disappears, and the pale-red returns. If this solution be diluted with water, and employed instead of ink, the characters written with it become visible, of a green colour, on warming the paper gently; but, upon cooling, that colour disappears, and returns again when warmed; and so on, alternately. However, if the paper be heated too strongly, the traces made on it acquire a brown and permanent colour.

b) The solution of oxyd of manganese alone, in concentrated muriatic acid, is, for the most part, entirely colourless:

less: neither does it acquire any tinge by warming it. The traces written on paper with this solution, previously diluted with water, continue invisible if the paper be exposed to a gentle heat only: but by a stronger heat they turn brown, and lose no more that colour, even after cooling.

## D.

All these phenomena sufficiently evince the presence of cobalt in the above compound reddish precipitate. However, since the colours exhibited by this precipitate are, in all their changes, paler than those which are produced by the oxyd of cobalt prepared from genuine cobalt-ores, it appears that the cobaltic is its smaller part. The manganese, on the contrary, constitutes the greater portion: and it seems that in this precipitate there obtains an intimate union between these two metals: for, although a great part of the manganese may be made separable by strong ignition, by which it is rendered insoluble in nitric acid; yet I could not succeed in separating entirely the remaining part of manganese from the ingredient cobalt, by repeated ignition and boiling in nitric acid.

It is on account of the manganese, so intimately combined with the cobalt, that neither the crude fossil, nor the reddish precipitate separated from it, imparts a true blue colour to vitrifying substances.

Yet, notwithstanding this, the mentioned arsenical addition (5. b) affords a practicable means of rendering the ingredient portion of manganese ineffectual in tinging glasses. The reason of this is, that the manganese combines, and enters into a state of complete saturation with the oxygen, which it seizes from the admixed arseniat of soda. And as, in this situation, it does not, of its own accord, tinge vitri-  
fying



fying substances, it likewise no longer prevents the cobalt from imparting a pure sapphire-blue colour; as is confirmed by the following experiments.

1. To *five* parts of that peach-flower coloured precipitate, previously dissolved in muriatic acid, I added a solution of *two* parts of arseniated soda, and effected a precipitation by means of carbonated soda. The precipitate, in this instance, acquired a lavender-blue, instead of a reddish colour; and, when added to a globule of borax, melted upon charcoal, it immediately coloured it of a pure sapphire-blue.

|                                    |   |                              |
|------------------------------------|---|------------------------------|
| 2. a) <i>Silex</i> . . . . .       | } | $\frac{1}{2}$ ounce of each. |
| <i>Calcined borax</i> . . . . .    |   |                              |
| <i>Reddish cobalto-manganefian</i> |   |                              |
| <i>precipitate</i> . . . . .       |   |                              |

10 grains,

mixed and vitrified in a porcelain-pot, afforded a glass of a weak and cloudy amethyst-colour,

|                                   |   |                              |
|-----------------------------------|---|------------------------------|
| b) <i>Silex</i> . . . . .         | } | $\frac{1}{2}$ ounce of each, |
| <i>Calcined borax</i> . . . . .   |   |                              |
| <i>Of the above lavender-blue</i> |   |                              |

*arsenical precipitate* . . . . . 10 grains,

yielded a glass of a very pure sapphire-blue colour, though not of that intensity which an equal quantity of oxyded cobalt, prepared from the common good cobalt-ores, imparts to similar glass-frits,

|                                     |   |                              |
|-------------------------------------|---|------------------------------|
| 3. a) <i>Silex</i> . . . . .        | } | $\frac{1}{2}$ ounce of each, |
| <i>Carbonated pot-ash</i> . . . . . |   |                              |
| <i>Rough fossil</i> . . . . .       |   |                              |

2 drachms.

produced a smalt-blue glass, the violet colour of which too much inclined to a dirty brown-red.

|                                     |     |                              |
|-------------------------------------|-----|------------------------------|
| b) <i>Silex</i> . . . . .           | }   | $\frac{1}{2}$ ounce of each, |
| Carbonated <i>pot-ash</i> . . . . . | }   |                              |
| <i>Rough fossil</i> . . . . .       | 2 } | drachms,                     |
| <i>Arseniat of soda</i> . . . . .   | 1 } |                              |

gave a smalt-blue glass, of a pure violet colour.

4. It yet remained to examine what colour would be produced by the cobaltic portion of this compound metallic oxyd, in the encaustic painting on porcelain. For this purpose, a part of the *lavender-blue arsenical precipitate*, prepared as before (No. 1.) was conveyed upon porcelain-vessels, previously ignited, and then fused upon them. The painting returned from the furnace in every respect of a pure cobalt-colour, though rather weak.

Besides these experiments, I performed a number of others with several variations, with a design of ascertaining the proportion of cobalt in the ore here examined, as well as of separating its oxyd of cobalt in a state entirely free from all admixture of manganese. But, since the result would not answer my wishes, I abstain from giving here an account of those experiments; and am, at present, satisfied with having demonstrated the presence of *cobalt* in this *black, earthy ore of manganese* from *Rengersdorf*.



## LXXI.

## CHEMICAL EXAMINATION

OF THE

## NATIVE SULPHAT OF COBALT.

*(Kobaltvitriol)**From HERRENGRUND, in Hungary.*

AT *Herréngrund*, near *Neusohl* in *Hungary*, a vitrolitic salt occurs, in pale rose-red, transparent crystals, of a *stalactitical* form; which is considered by some as a *sulphat of manganese*, but by others as a *sulphat of cobalt*.

To remove this doubt, I undertook the following examination of this fossil; and the result decided for the *latter* opinion.

*Hundred* grains of this metallic salt, when dissolved in water, and precipitated by carbonat of pot-ash, afforded seven grains of a loose, pale-blueish precipitate, which turned black on exposure to a red-heat. This precipitate, when fused upon charcoal, imparted to the glass-globule produced by the vitrification of a phosphoric neutral salt, as well as to that which is obtained in the same manner from borax, a pure sapphire blue colour. Its remaining part, that had not been employed for these experiments, yielded, upon solution in dilute muriatic acid, a sympathetic ink; the traces of which directly assumed a yellowish-green colour on warming the paper, but disappeared again as the paper cooled.

## LXXII.

## CHEMICAL EXAMINATION

OF THE

## MINERAL SPRINGS AT IMNAU\*,

In SUABIA.

AMONG the many various *mineral waters* with which beneficent Nature has provided several parts of *Germany*, there are some which, by accident and good fortune, have acquired fame and credit; while others, on the contrary, though not less valuable, have either continued to be totally unknown, or have undeservedly fallen into neglect and oblivion.

To these latter belong the *mineral-springs* at *Imnau*, a borough in *Suabia*, situated between *Tübingen* and *Rothweil*, in the estate *Haigerloch*, which is the property of *Prince Hohenzollern-Sigmaringen*.

Although these springs had been famous as early as the times of *Taberna-montanus*, I have not yet seen of them any account earlier than that given by *Caspar*†. But how little satisfactory his information can be with regard to the

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\* *Chemische Annalen*, I. Band. page 1792., 333.

† *Beschreibung des Saeurbrunnens zu Imnau*, &c. durch Sam. Caspar. Med. Dr. und Physicus zu Sulz am Neckar. Ulm. 1733, 8vo.



nature and constituent parts of the water, may be concluded even from the date of its publication; as, in general, at that time a well-founded chemical analysis of water could not even be thought of.

By the care of *Dr. Mezler*, physician to the Court of Hohenzollern-Sigmaringen, I obtained, of the mineral-water at Imnau, a quantity sufficient for examination, in five well-stopped, and numbered bottles; the waters of which were taken from as many contiguous springs, flowing into one common reservoir.

When the water arrived at Berlin it was found bright and clear; it frothed strongly on being poured into glasses, and had an agreeable and strong taste of carbonic acid. From this description only the water from the springs 4 and 5 ought to be excepted; because, with respect to smell, as well as taste, it seemed to be impregnated with sulphurated hydrogen-gas.

Each of the waters contained in those bottles I have first previously tried by means of *re-agents*. They were then subjected to analytical examination, in order to produce their constituent parts in a separate state.

A.

*Examination by means of Re-agents.*

I. *Tincture of Litmus.*

a) The *crude* water of all the five bottles, acquired by the tincture of litmus, a fine red colour.

b) When it had been *reduced* to one half by *boiling*, and filtered, it continued blue, on the addition of that tincture.

II. *Paper tinged with a decoction of Brasl-wood.*

a) The colour of the *crude* water changed the red colour of the paper to a violet.

b) *Boiled* water produced no change in the colour of that paper.

III. *Lime-water.*

On mixing equal parts of lime-water, and the water from each bottle separately, the mixture was rendered cloudy and of a milk-white; but it rapidly became again clear.—However, by the addition of more lime-water, a quantity of carbonated lime fell down.

IV. *Concentrated Mineral Acids*

disengaged from the water of each bottle numerous air-bubbles.

V. *Carbonat of Ammoniac, and Carbonat of Soda,*

produced a precipitate, which was thrown down entirely white, from the waters of the 1, 2, and 3 bottles; but that of the 4 and 5 bottles had an ash-grey colour.

VI. *Caustic Ammoniac, and caustic Soda,*

yielded the same precipitates as at V. but in a less quantity.

VII. *Spirituos Tincture of Nut-galls.*

The water of the bottle, No. 1, suffered no change from it, except that it acquired a weak yellowish shade. But in the waters of the bottles marked 2, 3, 4, and 5, a purple



ple precipitate was thrown down by this tincture, and the supernatant liquor acquired a violet colour, inclining to the green.

VIII. *Oxalic Acid*

immediately effected a copious precipitation.

IX. *Muriat of Barytes*

produced a precipitate in but a moderate quantity.

X. *Sulphat of Magnesia*

a) Threw down from the rough water, after 24 hours, a precipitate sufficient to be observable.

b) But the boiled water, combined with the same salt, was not rendered turbid, and it continued clear.

XI. *Nitrat of Silver.*

The water of bottle 1 continued at first unaltered, but afterwards it became a little opalescent. Those of the bottles No. 2 and 3 were altered very little; they, however, acquired a brownish tinge. The waters of bottles 4 and 5 were immediately rendered blackish, and deposited a black sediment.

XII. *Acetate of Lead.*

In the waters of the bottles 1, 2, and 3, it produced a white, and in those of the bottles 4 and 5 a dirty, light-brown sediment.

XIII. *Running Mercury,*

preserved in the waters of the bottles 1, 2, and 3, its bright lustre; but it became tarnished of a blackish hue, when immerfed into the waters taken from the 4th and 5th bottles.

XIV. *Leaf of beaten Silver.*

Small pieces of this continued unchanged in the waters of the 1, 2, and 3 bottles; but in those of the 4th and 5th they became tarnished, first of a gold, and then of a copper-colour.

## B.

*Analytical Examination.*

As a detailed explanation of every separate experiment would occasion unnecessary repetitions; to avoid these, I shall relate only, in a few words, the method which I pursued in these researches. To this I shall add, in a summary way, the constituent parts which I have discovered in the water of each particular spring, together with their proportion to each other.

I. *Examination of the gaseous constituent part.*

It has already resulted from the preceding researches, that this mineral water is richly impregnated with carbonic acid gas. To ascertain the quantity of this gas, its extrication and collection were performed by means of the mercurial pneumatic apparatus.

On examining the waters taken from the bottles No. 4 and 5, the mercury in the cylinder became incrustrated, at  
its



its upper surface with a brown pellicle, during the operation ; but this did not take place with the waters of No. 1, 2, and 3.

The gas, that was disengaged from the water of each bottle, was totally absorbed by lime-water, and produced carbonat of lime. But in the common air, that occupied the space left in the retort after the introduction of the mineral water, and which was driven over along with the carbonic acid gas, I could not discover any extraneous matter.

## II. Examination of the fixed constituent parts.

a) One hundred cubic inches of water (reckoning the weight of water, filling the capacity of one cubic inch, equal to 290 grains of distilled water), from each spring separately, were evaporated at a moderate temperature in a glass-dish. The water

of the bottle No. 1, left  $31\frac{3}{4}$  grains

$$\cdot \cdot \cdot \cdot \cdot 2, \cdot 34\frac{1}{2}$$
$$\cdot \cdot \cdot \cdot \cdot 3, \cdot 36\frac{1}{4}$$

• • • • • 4, •  $39\frac{3}{4}$

. . . . . 5, . 38

of a dry residue. That of No. 1 had a white, those of No. 2 and 3 a light reddish-grey, and those of No. 4 and 5 a reddish colour, of a little deeper cast.

b) All these residues were first treated with alcohol, during 24 hours. The ardent spirit became imbued with a faint yellowish colour, and when separated by filtration, and evaporated, it left behind it so slight a portion of a brown mass, that its farther decomposition was not well practicable. For this reason I collected it, by means of alcohol, into one mass, from all the five evaporating-dishes, and after having suffered the spirit again to exhale, I obtained

I

a residue

a residue weighing four grains. When this residue had been re-dissolved in very little alcohol, there remained  $1\frac{1}{2}$  grain of *muriated soda*: and on combining the spirituous solution with sulphuric acid,  $1\frac{1}{2}$  grain of *resinous matter* was separated. But the sulphuric solution yielded sulphat of magnesia; for which one grain of *muriated magnesia* may be put in the computation.

c) After this extraction of the several residues, by means of ardent spirit, I affused water upon each of them separately, and agitated the mixture several times. After 24 hours the aqueous extracts were, by means of the filter, separated from the undissolved portion, and made to crystallize: first, with the assistance of a gentle heat, and then by spontaneous exhalation in the open air. Every one shot into prismatic crystals, which consisted merely of *sulphated magnesia*; with the exception of that which had been obtained from No. 1, and which alone was accompanied with a nearly unobservable trace of *selenite*, or gypsum. These saline lixivia left at last a brown moisture behind, which hardly amounted to a few drops, and contained so small a quantity of *gummos-extractive* matter, that it could not be estimated.

d) Upon the portion that remained undissolved in water, I poured alcohol, and afterwards I dropped nitro-muriatic acid into it, until all effervescence and action of the acid ceased. On this process a small quantity of a muddy residue remained behind; which, when collected upon the filter, and ignited, left *siliceous earth* behind it.

All these solutions, previously filtered, were saturated with caustic ammoniac. By this combination, an hardly observable turbidness was produced in the solution of the residue left from the water of the bottle No. 1. But in those of the other four residues a ferruginous precipitate ensued;



which was carefully collected upon the filter, then washed, dried, ignited, and weighed. This I dissolved again in nitro-muriatic acid, in order to separate a small portion of *siliceous earth*; which still has been mixed with it, and was afterwards collected, ignited, and weighed, for the purpose of ascertaining the true weight of the iron, which the preceding precipitate had contained, by subtracting the weight of the filix from the whole weight of the former. After which, this portion of iron was reduced, in the computation, to a corresponding quantity of *carbonated oxyd of iron*.

e) After having thus separated the ferruginous part, I reduced the solutions, in some degree, by evaporation; I combined them with a fourth part of their volume of alcohol, adding, then, concentrated sulphuric acid by drops, which immediately threw down a quantity of selenite. I continued dropping in the acid, as long as any of this sulphat of lime would fall down. The selenite was collected on the filter, and when it had beenedulcorated with a mixture of water and alcohol, I again decomposed it, by boiling with an aqueous solution of carbonated soda. The *carbonat of lime*, thus separated, was washed, dried, and weighed.

f) To discover whether the fluid remaining from the separated gypsum contained any magnesia, I evaporated it to some part, and combined it with carbonat of soda, at the degree of boiling heat. However, no precipitation took place.

According to the results of these inquiries, *one hundred cubic inches* of the waters of the *mineral springs at Imnau* contain:

## LXXII. Examination of the

## I. Water from the Bottle No. 1.

|                                                            |              |
|------------------------------------------------------------|--------------|
| Sulphat of magnesia, with }<br>a trace of selenite . . . } | 5,75 grains  |
| Muriat of soda . . . .                                     | 0,30         |
| Muriat of magnesia . . .                                   | 0,20         |
| Carbonat of lime . . . .                                   | 25           |
| Silex . . . . .                                            | 1            |
| Resinous matter . . . .                                    | 0,30         |
|                                                            | <hr/>        |
|                                                            | 32,55 grains |

Carbonic acid gas, 104 cubic inches.

## II. Water from the Bottle No. 2.

|                             |              |
|-----------------------------|--------------|
| Sulphat of magnesia . . . . | 5 grains     |
| Muriat of soda . . . .      | 0,30         |
| Muriat of magnesia . . . .  | 0,20         |
| Carbonat of lime . . . .    | 27,75        |
| Carbonated oxyd of iron . . | 0,75         |
| Silex . . . . .             | 1            |
| Resinous matter . . . .     | 0,30         |
|                             | <hr/>        |
|                             | 35,30 grains |

Carbonic acid gas, 105 cubic inches.

## III. Water from the Bottle No. 3.

|                             |              |
|-----------------------------|--------------|
| Sulphat of magnesia . . . . | 5,50 grains  |
| Muriat of soda . . . .      | 0,30         |
| Muriat of magnesia . . . .  | 0,20         |
| Carbonat of lime . . . .    | 28,25        |
| Carbonated oxyd of iron . . | 1            |
| Silex . . . . .             | 1            |
| Resinous matter . . . .     | 0,30         |
|                             | <hr/>        |
|                             | 36,55 grains |

Carbonic acid gas, 104 cubic inches.

## IV.



## IV. Water from the Bottle No. 4.

|                                    |      |        |
|------------------------------------|------|--------|
| <i>Sulphat of magnesia</i> . . .   | 6    | grains |
| <i>Muriat of soda</i> . . . .      | 0,30 |        |
| <i>Muriat of magnesia</i> . . .    | 0,20 |        |
| <i>Carbonat of lime</i> . . . .    | 31   |        |
| <i>Carbonated oxyd of iron</i> . . | 1,50 |        |
| <i>Silex</i> . . . . .             | 1    |        |
| <i>Resinous matter</i> . . . .     | 0,30 |        |

---

40,30 grains

Carbonic acid gas, 112 cubic inches.

## V. Water from the Bottle No. 5.

|                                    |       |        |
|------------------------------------|-------|--------|
| <i>Sulphat of magnesia</i> . . .   | 5,75  | grains |
| <i>Muriat of soda</i> . . . .      | 0,30  |        |
| <i>Muriat of magnesia</i> . . .    | 0,20  |        |
| <i>Carbonat of lime</i> . . . .    | 29,75 |        |
| <i>Carbonated oxyd of iron</i> . . | 1,50  |        |
| <i>Silex</i> . . . . .             | 1     |        |
| <i>Resinous matter</i> . . . .     | 0,30  |        |

---

38,80 grains

Carbonic acid gas, 115 cubic inches.

It will be observed, that the sum of the separate constituent parts, in each of the above *five* computations, is a little greater than the weight of the entire dry residue, that has been at first obtained (B. No. 2. a.). This is to be accounted for by the water of crytallization, which enters into the sulphat of magnesia.

C.

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## C.

In this summary statement will be found wanting the *sulphurated hydrogen gas*, suspected before in the waters of the 4th and 5th bottle, or spring (page 581); the presence of which, however, seemed to be indicated by their taste and smell, as well as by the dark colour of the precipitate thrown down by acetated lead, and by the tarnishing of the reguline mercury and silver-leaf (A. No. 13 and 14), immersed into them.

However, since I have experienced in other instances, that, in mineral waters, these and similar indications originate but rarely from real sulphurated hydrogen gas, and that more frequently they arise from the admixture of putrefying organic matters; I entertained a doubt: whether that putrid vapour be an essential ingredient in the waters of the springs No. 4 and 5? Of this doubt I informed Dr. *Mezler*, requesting him to examine this object on the spot. And it resulted from the researches, which he made, that this smell, resembling that of sulphurated hydrogen gas, was owing merely to the putrescent state of a cement, which had been employed in the construction of some pipes, through which it was found necessary to force the water of the *fourth* and *fifth* springs into their appropriate reservoirs. This cause has been since removed; hence these springs are, at present, entirely free from all extraneous contamination. When the whole of the water had been pumped out of the reservoirs, and, consequently, when Dr. *Mezler* was enabled to examine water, that had recently issued from these springs, he found, neither by the taste nor by the smell, the least trace of that hepatic odour. Besides this, he filled, under the surface of the water, four bottles; the *first* of which contained some clear pieces of white arsenic;



arsenic; the *second*, some crystals of purified acetate of lead; the *third*, beaten leaf-silver; and the *fourth*, running mercury: stopping all these bottles closely. After 24 hours, the arsenic was found as white as before; the precipitate produced by the acetated lead was of a beautiful white; and the metallic lustre of the silver and mercury was not in the least impaired.

END.

# ERRATA.

| Page | Line  |   | read                                                                                                          | effect.                |
|------|-------|---|---------------------------------------------------------------------------------------------------------------|------------------------|
| 54   | 20    | — | <i>affect</i>                                                                                                 | 35                     |
| 120  | 31    | — | 36                                                                                                            | 112                    |
| 139  | 8     | — | 122                                                                                                           | 160 $\frac{1}{8}$      |
| 147  | 13    | — | 160 $\frac{5}{8}$                                                                                             | 2 $\frac{2}{3}$        |
| 278  | 22    | — | 2 3                                                                                                           | 15. 1. 7.              |
| 309  | 17    | — | 5—7                                                                                                           | 1 $\frac{1}{4}$ grain. |
| 342  | 8     | — | 1 grain.                                                                                                      | would not shoot.       |
| 354  | 29.30 | — | would shoot                                                                                                   | muriatic.              |
| 359  | 18    | — | carbonic                                                                                                      | 2,490                  |
| 362  | 14    | — | 2,40,0                                                                                                        | caustic foda.          |
| 404  | 1     | — | carbonated free foda                                                                                          | 47 grains.             |
| 450  | 16    | — | 47 lb.                                                                                                        | fulphuric              |
| 461  | 6     | — | muriatic                                                                                                      | fulphureous.           |
| 475  | 8     | — | after <i>leucite</i> , read, whose earthy parts, like those of<br>lepidolite, are also filex and alumine, &c. | fulphuric.             |
| 479  | 12    | — | fulphuric                                                                                                     |                        |
| 500  | 24    | — | muriatic                                                                                                      |                        |

219 transfer note (\*) to page 218.

400 transfer note to — 399.

Some other typographical errors, and mistakes of less importance, are recommended to the Reader's kind indulgence.











